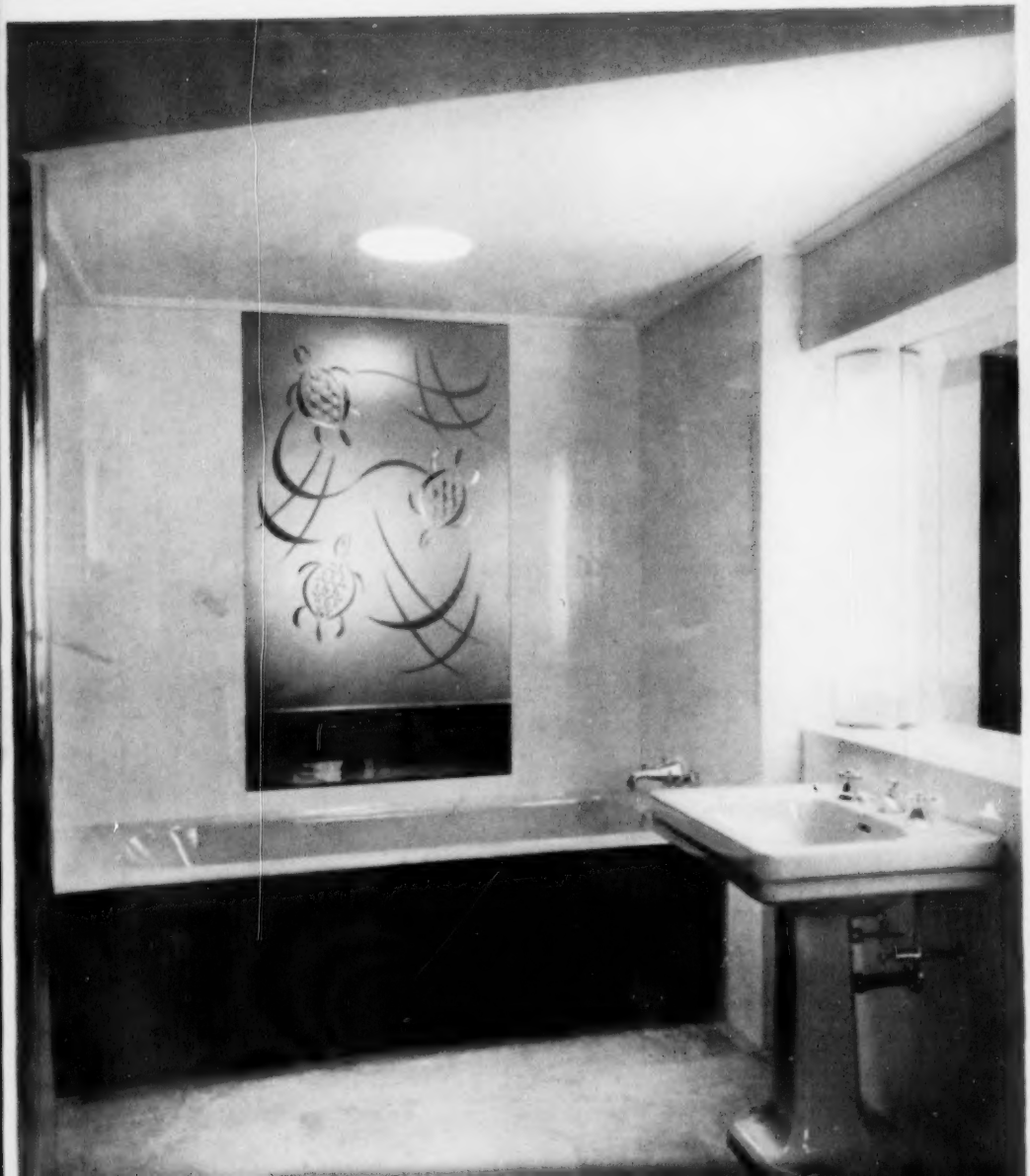
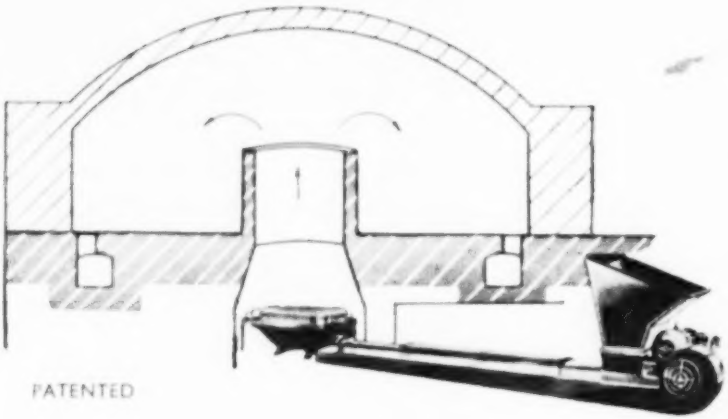
CERAMICS

(AP)

October, 1950



KILN FIRING



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Ceramics

VOL. II OCTOBER, 1950 NO. 20

RESEARCH

THIS word is now used to describe what is becoming more or less a religious creed—fundamental research, operational research, and now one reads that the D.S.I.R. have suggested a complete scientific service for their industries with research on everything bearing on production, including works organisation and economic and sociological studies!

Simultaneously this D.S.I.R. annual report calls bluntly for more basic research. "Research for research's sake" is rapidly becoming the order of the day and no doubt laudable moral arguments can be given for this as indeed for most theories of social reform.

This is not a perfect world and its inhabitants are not perfect people for which we must be truly thankful. Thus cool moral logic is inapplicable and it is the attempted reconciliation of imperfection with morality which has caused the planners to lead us into the economic wilderness. A 100 years ago a man did research as a philosophical hobby. Today the opposite prevails! Highly qualified arch-priests in white coats work in modern buildings with expensive apparatus—which adds to the social value of the institution—frequently many miles away from the hum-drum productivity of the industries their Research Association represents.

We live in an era of expediency more so than ever before. It may be wrong but we cannot change it! Thus whatever our development efforts made under the grandiose name of "Research" they must be related to increased efficiency in the industrial arts or, more simply, research efforts must be conducted towards increased output per operative. This is one aspect of fundamental research but not, it is feared the conception envisaged by D.S.I.R.!

CONTENTS

POTTERS LOOK TO THE FUTURE!

by **ARGUS**

ALL is going swimmingly in the Potteries just for the time being. The export market is a money spinning concern and the despised and rejected home market will take anything that is going! The five towns are "boom" towns in every sense of the word. But it is always better to pause and consider what is going to be done in the future whilst the cash register is working with that pleasurable frequency.

What has happened?

After 5 years of limited war-time production there have been 5 years during which time there has been a really worthwhile market for pottery. Potters who before the war found themselves heading towards—if not already in—Cary Street, have been carried along on a prosperity wave which still continues. Most of the larger, and many of the smaller potteries, have profited by this advantage to plough back into the business profits which a flinty Chancellor of the Exchequer would have otherwise purloined. As a result modernisation has proceeded to a tremendous extent.

Mass Production

Recently I had a chance to see a very large and a moderately sized pottery. In the former the decoration of ware had really adopted the mass production technique. On a continuous conveyor the ware was brought to the decorators in cartons with coloured tags relating to each operative. In pleasant surroundings and with the encouragement of piece rates they were producing a fantastic output of really first-class goods. Time and motion study had been applied to the greatest extent. Goods were cross indexed to the operative; wages were high but above all one stood amazed at the produced volume of decorated ware which was coming from each sq. ft. of space. The piles of work to fill the kiln instead of being higgledy-piggledy on the floor graced the air above on an elaborate system of overhead conveyors. Literally the week-end batch for the kiln was "in the air."

Quality Retained

Advantage had been taken of "Ryckman" Gold Edge lining machines. A 17-year-old operative was producing excellent results and earning between £4 and £5 a week. In short the slogan "Pottery for the Millions" was being worked out to an almost awe inspiring extent yet in all this, quality was still the redeeming factor. So much then for the larger concern.

Now for the medium sized organisation.

Intermittent ovens were being dismantled. A biscuit tunnel kiln was already in operation and a glost tunnel was nearing completion. An economic and convenient arrangement of the sliphouse, making shops and so on, had cut out unnecessary transport within the pottery. The close proximity of the dryers to the making machines had reduced handling. Without exaggeration it can be said that within this organisation alone each unit of labour was performing something like 300 per cent. more output than before the war.

Unfortunately this is not the case for a number of other potteries.

People say that when ware is directed towards the home market that that will be the signal for a pottery depression. This is dangerous talk indeed and is not worthy of the stuff of which the pioneer potteries of Staffordshire were built. There are 50 million people in Britain and one must face the fact that they have had little opportunity of appreciating good pottery from bad in the last 10 years. The housewives of Britain below 30 years of age have never had an opportunity of being able to buy the very products upon which Staffordshire survives. This is bad, for in the interests of the Pottery Industry, although austerity demands that the best goods should go abroad, every possible step should be taken to ensure that the British public at least have a chance of seeing and handling good ware as often as possible.

Let People See Good Ware

Small compact exhibitions in departmental stores and shops throughout the country should be frequent occurrences. In this respect I am not thinking of the high quality products, which satisfy essentially a relatively small luxury market, but of the good quality pottery which will have to be sold to the mass market. Even today, because the home market has been starved, inferior ware is selling at absurdly high prices, and the control system has opened up an opportunity for the producer of inferior goods to prosper and for the shadier customers to unload poor quality ware by the most diverse and disruptable means.

What is going to happen when the export market is no longer there in quantity?

Japan already has made its presence felt and Germany is likewise moving in the same direction. It is wrong to imagine that the economy of the potteries can forever be tied to the overseas market. Charity begins at home and a healthy home market is the most important prop to the British Pottery Industry. Make no mistake about it; those firms who have taken the trouble to modernise their factories and to produce goods for the mass market with the minimum amount of handling in the factory during processing—they alone will survive! Those who have not and who are uneconomic in terms of labour will go to the wall when the preferential market closes.

Get Together

There is no need for another depression to hit the British Pottery Industry. In the past price cutting amounting to throat cutting was all too frequent. As a result everyone suffered including producers of good and poor quality goods. It is not a question of price fixing or rigging the market but the question of potters getting together to ensure that an agreed quality should be preserved and a fair price obtained by their conjoint efforts otherwise the unscrupulous might again bring the Industry to its knees.

If the efficient and foresighted producers will get together now—and stick together—and compel others to fall into line, there is a chance of salvation. But if the icy blast of cut-throat competition ever enters again all will suffer. It is known that the present control system is keeping quite a number of potteries producing inferior goods at inflated prices in business—but the Industry as a whole must take the necessary steps to ensure that uneconomic price cutting by these people in the future is not going to disrupt the industry itself. It is one of the paradoxes of the Government's control policy that fortunes are being made by the modern "spiv" at the expense of the ordinary people of the community! Visits to fun fairs, Petticoat Lane and street markets are enough to prove that the unscrupulous are getting quantities

of decorated pottery junk. A perusal of the relatively few cases found by the Board of Trade shows how! This is good for neither pottery worker or pottery management. The fabricators of this junk will be the first to begin the price throat cutting for they are the "fly-by-nights" with nothing to lose!

It is a surprising thing that a group of industries situated in such close proximity one to another and related not only by blood ties but by the stark necessity of self-preservation should be so suspicious one of the other and so reluctant to get together in a common interest.

The future of British Pottery lies undoubtedly in maintaining quality and reducing the price. This can be achieved for there are many examples of this process at work throughout the potteries.

Training for Youngsters

Nevertheless it is most important that the younger practical men in the Industry should have adequate opportunities for training. At present we are often surprised because there are ample opportunities for highly trained technicians and executives but virtually nothing for the boy leaving school at 15 who wants to become a potter. Admittedly there are courses of instruction but it is always difficult to guarantee that such classes will be attended.

There are several reasons for this. One no doubt is that the boy paid piece rates earns more whilst at work than if on the basic rate whilst attending a Technical College. The other is that the man in the Pottery for whom the boy works can get a bit of useful productive output from him; even cajoling him away from his class by the offer of a 2s. piece! This is the kind of short-sightedness which brought the slump before, not only in the Potteries but to many other industries in Britain.

The essentials of the future in the British Pottery Industry are firstly to ensure that the younger entrants from the primary school have an adequate training course and for manufacturers to recognise completion of this course in a tangible form in so far as final pay is concerned. Secondly the progressive potteries must get together. It will mean a certain interchange of information, a certain freedom of discussion and a certain compromise of one pottery with the next. But the results can be worthwhile. Certainly if ever again price cutting and throat cutting are allowed to intervene the effect could be the annihilation of the industry as a productive force.

State Intervention

Then again comes the question that any British Government, be it Conservative or Labour, is committed to the policy of full employment and if the various potteries do not get together of their own volition the State is quite likely to do so on their own behalf.

Any compromise one with another is preferable to State intervention. In the first case individual potters lose some individuality but in the latter they lose all! And Government intervention is as certain as the day following the night if the policy of full employment is seriously threatened for unemployment is the fertiliser upon which Communism thrives.

"ECONOMIC" BOILERS

WE have received from Davey, Paxman and Co. Ltd., a copy of their Publication No. 1259, describing their "Economic" boiler, and showing by excellent photographs many "Economic" installations in all sorts of industries. Certainly the array of typical installations is very impressive. Further, some information is given about the Davey Paxman "Ultranomic" boiler, which is an advanced design for specific purposes. Although it was introduced 20 years ago, the Paxman steel sectional boiler for central heating has been considerably improved and brought right up to date and this is available for firing by coal, coke, liquid or gaseous fuel. If you wish to have a copy of this new brochure, write to Davey, Paxman and Co. Ltd., at the Standard Iron Works, Colchester.

THE "ATRITOR" UNIT PULVERISER

Its Application to the Ceramic Industry

By

OUR INDUSTRIAL CORRESPONDENT

THIS grinder, made by Alfred Herbert Ltd. of Coventry was originally designed for pulverising coal required for firing boilers, rotary cement kilns, and metallurgical furnaces. Recently it has been adapted to the simultaneous grinding and drying of clays and other products used in the ceramic industries. This has aroused considerable interest among manufacturers, and as a result of trials carried out on users' materials at Coventry, the scope of the applications of the "Atritor" is continually increasing.

Firing of Furnaces

The advantages of using pulverised coal for furnace work have been appreciated for a long time—over 100 years—and 75 years ago pulverised coal was used by an iron master in the Midlands. The cheapness of coal then however, offered little inducement to a change-over from the traditional methods of hand firing. The advent of the rotary cement kiln gave an impetus to the use of pulverised coal, and since about 1935 its use for all heating purposes has greatly increased.

Originally the pulverising of coal required an elaborate plant layout of elevators, storage bins and grinders. This was costly, and took up considerable space. Moreover the storage of coal dust required precautions against fire hazards.

Herbert's were quick to realise that the simplification of the machinery required for pulverising coal would be an immense advantage, and about 1920 the "Atritor" was conceived.

It was a compact machine embodying a feed mechanism, metal separator, dryer, pulveriser and fan. The pulverised fuel was delivered straight to the furnace and storage bins were eliminated. Since then the machine has been improved and the volume of sales to all parts of the world is a proof of its reliability, and of the fact that it fulfils the claims made by the makers.

The "Atritor"

As its name implies the "Atritor" pulverises by attrition. It consists of a feeder, metal separator, pulveriser and fan (Fig. 1).

The material, roughly crushed to about $\frac{3}{4}$ in. cubes and which may contain up to about 18 per cent. moisture, is fed into a hopper situated on the top of the machine. It is fed into the grinding zone by a plate and scraper mechanism. From the hopper the material is taken on to a horizontal rotating disc. The height of the layer of material on the disc is controlled by a lever, and the position of the scraper by a hand wheel. In this way the amount of material fed to the machine is easily regulated. A separator now removes heavy foreign bodies like lumps of metal, stones, etc. The

separation is done by air flotation for coal. A stream of air is drawn through the separator with such velocity that the coal is drawn into the grinding zone, while the heavier materials fall and pass out through a chute. For heavier materials such as ferrous metals, magnetic separation is used. The raw material then enters the pulverising chamber at the centre.

Grinding

Here the material is given a preliminary crushing by being beaten against a liner ring by a series of hammers. It is then drawn by the air stream, generated by the fan in the apparatus, over the periphery of the rotor into the zone where attrition completes the grinding process. In this zone an enormous turbulence is given to the particles by a number of impellers mounted on the rotor.

To prevent the gyration of a dust cloud with the rotor the impellers pass through a series of pegs, or interrupters, mounted on a fixed plate. The effect is to set up a very high turbulence among the particles, as a result of which they rub against each other, and are reduced in size at a rapid rate.

When the particles become fine enough they are drawn out of the turbulence towards the centre and the eye of the fan. Here they are taken up by a rejector, which prevents oversized particles being delivered from the apparatus. The rejector consists of one or more spoon-shaped arms rotating with the shaft and rotor. They are set near the eye of the diaphragm which separates the pulverising compartment from the fan. The number of

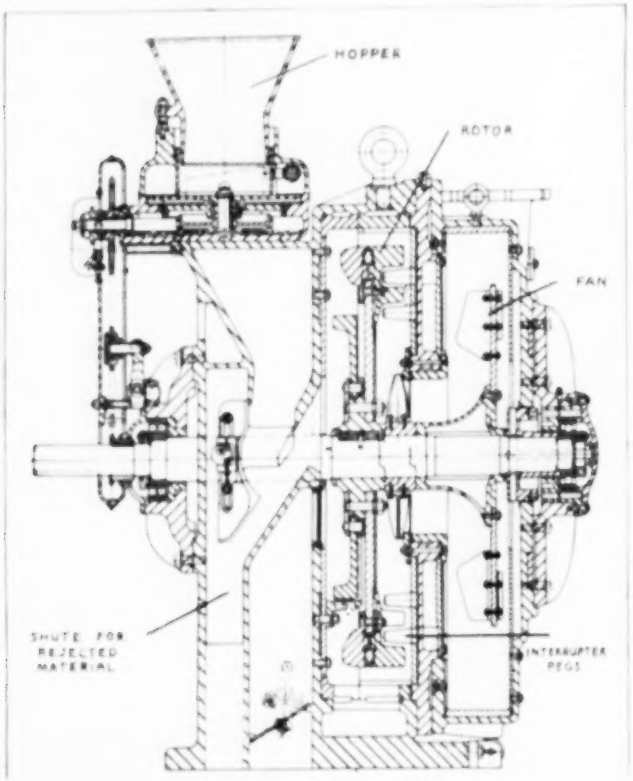


Fig. 1. Sectional drawing of the "Atritor" pulveriser

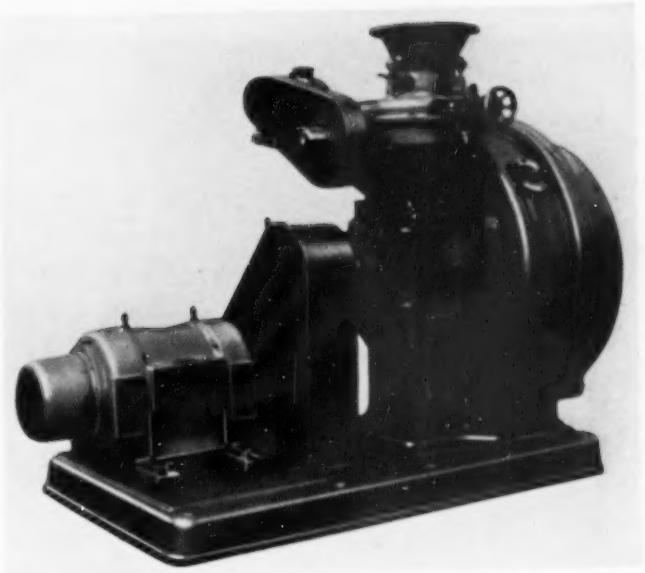


Fig. 2. The "Atritor" unit pulveriser, made in six sizes

rejector arms required depends on the size of particle ultimately required. The coarse particles are caught up by the arms, and returned to the attrition zone, the others pass to the fan and thence out of the apparatus. Coal is sent direct to the burners, while clay, etc. is collected in a cyclone dust separator.

Drying While Grinding

Drying during grinding is effected by passing hot air through the apparatus with the raw material. If no flue or other hot gases are available, a small coke stove is supplied for the purpose. As the amount of material in the "Atritor" at any given instant is very small, and as it is in a fine state of division, well mixed with hot air, drying is rapid. The degree of drying can be controlled by the rate at which air and material are drawn through the apparatus. The main shaft is mounted on ball or roller bearings. The rotor is a mild steel plate on which are mounted segments of a hard alloy iron.

Features of the machine are that it is quiet and dustless in operation, and occupies little floor space. It is very flexible and the power taken falls with reduction in the amount of material being pulverised. It requires little attention and can quickly be dismantled for cleaning when required. Unskilled labour only is required to operate it. It pulverises and dries in one operation and the makers claim that it is the most efficient, combined pulveriser and dryer on the market, especially for dealing with sticky, wet material. A further advantage with coal is that there is no possibility of fire or explosion. The "Atritor" (Fig. 2) is made in six sizes with outputs (for coal) ranging from:—

No. 6	15 h.p.	900 lb./hr.
to No. 18	140 h.p.	13,000 lb./hr.

It should be mentioned that, with clays and other ceramic materials, higher outputs have been obtained by suitably modifying the apparatus. The actual output will of course depend on the fineness of grinding required and the hardness of the material. Let us now consider some of the applications of the "Atritor" to the ceramic industries.

Coal is still the cheapest method

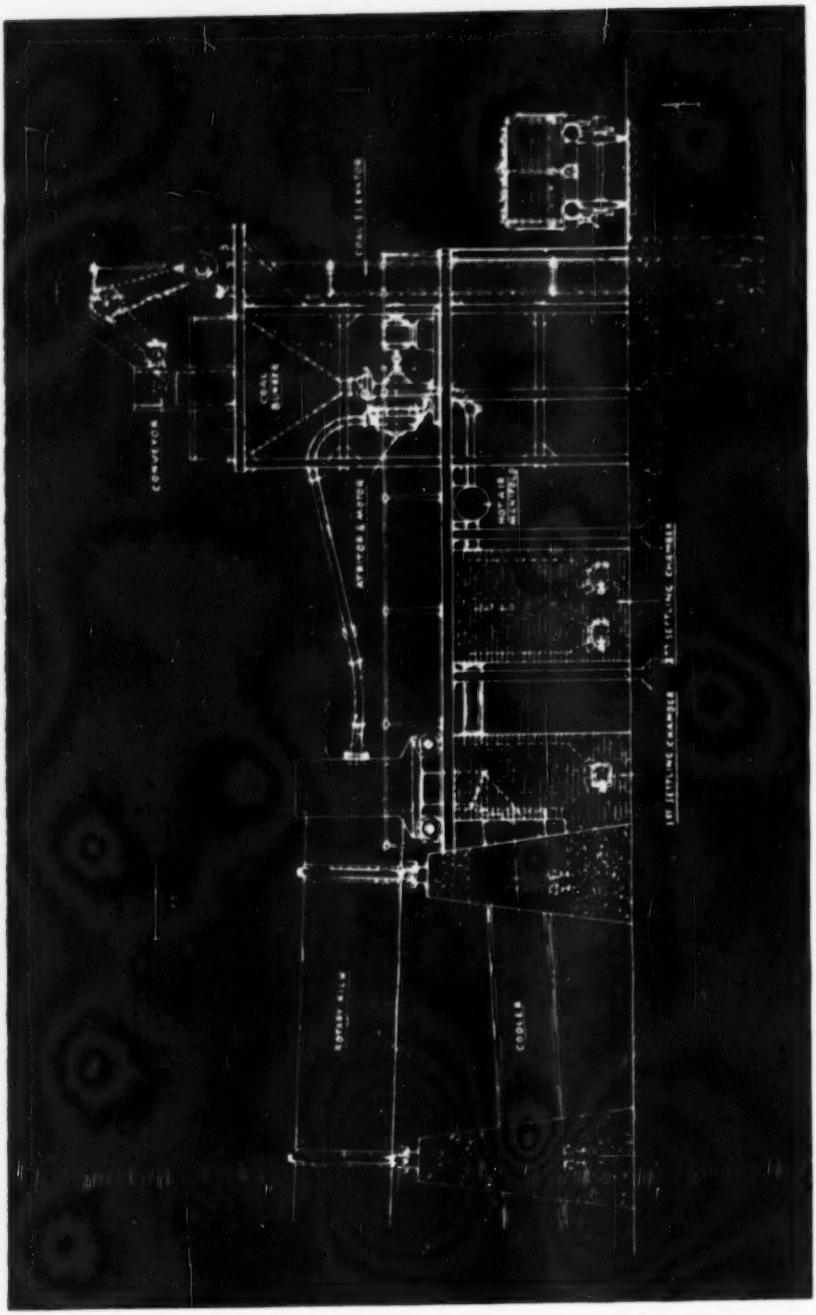


Fig. 3. Sectional view showing No. 16 Atritor firing a rotary cement kiln

of heating, particularly where a low grade and cheap variety can be used successfully as with the "Atritor". The relative costs of the principal fuels used in the ceramic industries are as follows:—

Coal, C.V. 13,500 B.Th.U./lb. at 60s. ton	2·38d./therm
Fuel oil, C.V. 18,900 B.Th.U./lb. at 8¼d. gallon	4·97d./therm
Towns gas at 475 B.Th.U./c. ft. at 2s. 1½d./1,000 c. ft.	5·33d./therm
Electricity at 0·6d./unit	17·58d./therm
Producer gas of 140 B.Th.U./c. ft. from coke at 85s. ton	4·34d./therm

Watertube Boilers

Large numbers of these pulverisers are now in use in all types of industrial concerns. They offer the following advantages:—

(a) Low grade fuels and slack can be burnt with maximum efficiency.

(b) Boilers can be lit up from cold and put on the line in 2 or 3 hours. They can be shut off immediately they are not required and load variations can be dealt with easily.

(c) Combustion is complete and smoke eliminated.

Used in conjunction with special types of burner the efficiency of Lancashire boilers can be improved by using pulverised coal.

Rotary Cement Kilns

The "Atritor" was originally designed to replace the intermittent grinding of coal in ball and tube mills, with attendant storage bins, feeders and fans. Its compactness and quiet running were a decided advantage, and moreover, it enabled it to be mounted on the kiln platform where it could be supervised by the kiln operator. Reduced capital charges and increased output are claimed when firing is done with "Atritor" pulverised coal. The hot air required for drying the fuel is obtained from the cement clinker cooler (Fig. 3).

Ball and China Clay

The extraction of china clay involves washing down the clay face with powerful jets of water. Subsequently rock particles are settled out in a tank, and mica, etc. removed in settling troughs called "mica drags." The slurry has to be dewatered after thickening in settling tanks. Originally this was done on heated kiln floors. In the damp plastic state the clay contains about 16 per cent. of water. The wet clay can be dried and pulverised in one operation by the "Atritor." A product containing less than 1 per cent. moisture and in which 98 per cent. will pass through a 300 B.S.S. screen is now being regularly produced by this means.

Ball clays, which are mined in the damp plastic condition can be treated similarly, and it is now possible to obtain them in a dry powdered state.

The cost of grinding clay depends on the moisture to be dried out and the degree of grinding required, but the figure is around 4s. 6d. per ton, not counting capital costs. Provided the manufacturer is prepared to pay for it, it seems that dried pulverised clay is the answer to the eternal grouse about excessive moisture in raw clay.

Dry Ground Clay in Whiteware Manufacture

It is interesting to note that, for the American dry-mix method for whiteware bodies the material is ground in edge-runner mills which are fed with hot air, and the fractions are sorted out in an air classifier. The apparatus here described would appear to be simpler and could be used with a classifier in the same way.

The possibility of obtaining dry, ground clays opens up interesting possibilities which are worth experi-

ment. Herbert's are only too willing to assist manufacturers by grinding batches of their materials.

Firstly, it would be interesting to ascertain whether it would be an economic proposition to mix earthenware and similar bodies with dry ground clays, mixing the ingredients in a single blunger. If successful this would save the use of several blungers, with their attendant labour and power requirements. It would also simplify slip house lay out.

country did not encourage its use, and so the experiments were not pursued.

The advantages of dry mixing were of course realised, namely simplification of the plant required, speed of preparation and hence increased output, and ease of changing from one type of body to another. In the "Atritor" we have a machine that gives fine grinding and can also be used for mixing and drying; and it is understood that one manufacturer has resumed experiments on

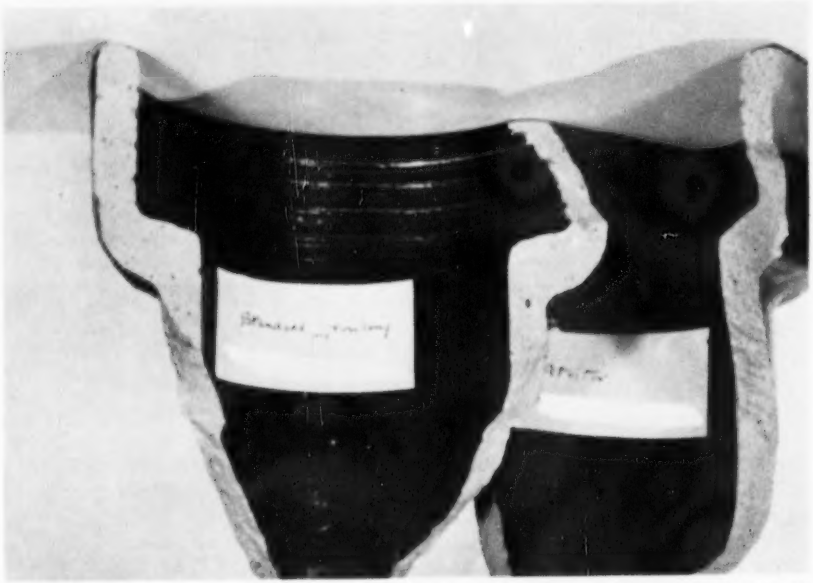


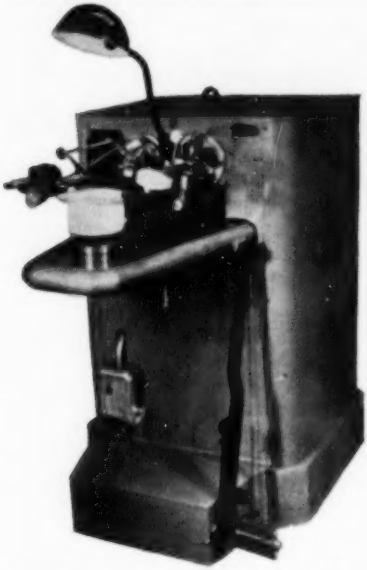
Fig. 4. Sections of salt glazed pipe made by using grinding pan and the "Atritor"

From time to time experiments have been made into the possibility of dry mixing pottery bodies in this country. To date the results have not been encouraging, and it has been felt that with the apparatus used hitherto the mixing of the ingredients in the type of body used has not been intimate enough. Using an American type of body containing talc the results were good, but with our type this did not hold. The availability of talc in this dry mixing, the flint being added in a damp preground form to prevent undue wear and iron pick up from the machine.

This development will no doubt be followed with interest.

Wall Tiles and Electrical Porcelain

A machine that would receive damp material and grind and dry it to a predetermined moisture content of about 7 per cent. would be ideal for pressing articles such as



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wall tiles and electrical porcelain, where the present method involves drying out press cakes, disintegrating, mixing the dust with water and possibly oil and then sowing to even up the moisture content. In its present form the "Atritor" does this too well, the resulting dust being too fine and giving "wind blown" articles. Research into this problem is now going on with what are stated to be not unpromising results.

Floor Quarries

These objections do not hold with some clays used for floor quarries, however. It is not claimed that all clays and shales will lend themselves to this treatment and a trial grinding carried out by the makers of the "Atritor" is advisable. The advantages of using a semi dry method of manufacture are sufficiently well known to any brick and tile manufacturer to need no further elaboration here. For the manufacturer of pressed quarries the "Atritor" offers a simple and effective method of production.

The raw clay containing 18-20 per cent. moisture is conveyed from the quarry and, if hard enough, is given a preliminary crushing, and passed into the "Atritor." Here it is dried to about 7 per cent. moisture and ground, and the dust collected in a Cyclone dust catcher. After standing for a day this is used for pressing the quarries.

Finer Texture and Harder

Quarries and covings made by this process seemed to be of good quality, and laboratory reports indicated that they were harder, as determined by Brinell hardness and shot blowing tests. On one such test the quarries appeared to have a finer texture and were about 50 per cent. harder than those made from the same clay by the traditional method. Using this method the time required and the size of plant are considerably reduced.

A recent innovation is the use of the "Atritor" to grinding clays used for pipe making. The finer grinding results in a closer texture in the finished pipe and reduces limestone and ironstone particles to a size where they give no trouble with "blow-outs," etc.

The machine has also been used for grinding together clay and grog, which is subsequently tempered, mixed, and extruded. The resultant plant layout is simplified in some cases by the elimination of conveyor and screens. Even where the clay is not completely dealt with by the "Atritor" the machine has proved invaluable in dealing with the tailings from pan grinders. These are rendered innocuous by fine grinding and returned to the mixture, often improving its characteristics.

Using clay and grog ground in the "Atritor" one firm has shown that a stronger, better pipe is obtainable (Fig. 4).

Refractory Products

The apparatus is also being used for grinding and drying clays used for the manufacture of refractory materials.

To sum up Herbert's claim that they have in the "Atritor" a machine that

1. will grind some ceramic materials more efficiently and cheaply than existing grinding plant;
2. will dry to a predetermined moisture content at the same time.

They do not claim that in its present form it will solve all mixing and making problems but every effort will and is being made, to solve prospective users' problems by modifications to the standard type.

Interesting applications have already been found, and it is felt that many more will follow when it is realised that this machine is an efficient unit, which will not only save money but will enable plant layout to be enormously simplified at the same time.

FUSION CAST REFRACTORIES

by

H. MOORE, D.Sc., A.R.C.S., F.Inst.P.
Professor of Glass Technology, University of Sheffield

Part I

THE use of ordinary aluminosilicate refractories for metallurgical processes and for glass making, depends primarily on two properties of clays: (1) a clay forms a plastic mass with water, and can be worked to shape in the cold, and (2) when fired at temperatures which can be attained without great difficulty, the clay is converted to a mass of highly refractory crystals embedded in a glassy matrix, without serious change of shape.

It is not necessary for me to discuss the nature of the crystals in any detail, they consist of mullite, sometimes with silica and sometimes with corundum, depending on the proportions of silica and alumina present in the original mass, together with small proportions of double silicates such as nepheline (or carnegieite). The glassy matrix is formed by interaction between the silica and the "fluxes," i.e. the non-alumina, non-silica constituents. It is mainly siliceous but contains most of the fluxes and a proportion of alumina which depends largely on the temperature at which the refractory has been fired.

Proportion and Properties

The proportion of glassy matrix is determined partly by the amount of silica available and partly by the proportion of fluxes present, though if the fluxes are present in only small quantity relative to the silica available, the glassy matrix will contain cristobalite and tridymite which have crystallised out as the refractory cooled down after firing. The properties of the glassy matrix are determined by the nature and amounts of the fluxes present in the original raw materials, or which have been added to promote crystal development during firing, particularly on the amounts of alkali. The requirement that the refractory shape should not become seriously distorted during firing, sets a limit to the permissible firing temperature, determined by the amount and nature of the glassy matrix formed.

Distortion

The distortion which occurs when a refractory shape is fired at too high a temperature is due to softening of the glassy matrix. If, however, the distortion could be prevented, the temperature might be raised sufficiently for the glass to take up a considerable proportion of alumina, thereby becoming much more viscous. The refractory would then be capable of retaining its shape at temperatures which, during the initial heating, would have caused it to "squat" into a shapeless mass unless supported in some way. The supporting of a refractory shape in such a way as to prevent distortion when heated beyond the squatting temperature is obviously quite impracticable; it becomes necessary, therefore, to resort

A lecture recently given at the Imperial College of Science and Technology as part of a lecture series entitled "The Firing of Bricks."

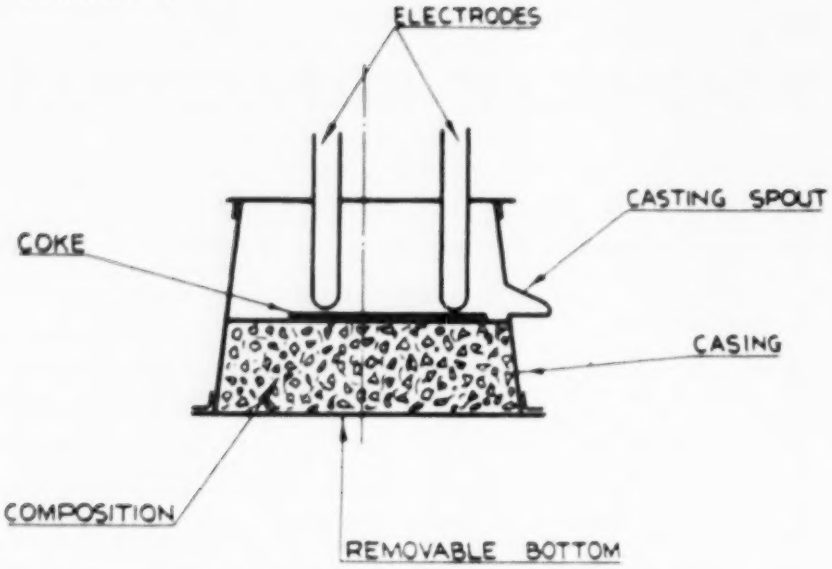


Fig. 1. Heroult-type electric melting furnace for Corhart, charged ready for starting up

to complete fusion and subsequent casting to shape, if sufficient alumina is to be taken up by the glassy matrix to ensure that the viscosity of the matrix shall be materially raised.

Since mullite is the "end product," so to speak, when clays are heated to temperatures of the order of 1,400° C. and is the alumino-silicate which, apart from corundum itself, offers the greatest resistance to solution by glasses and slags, there would be little purpose in making fusion - cast refractories from materials containing alumina in lower proportion than that corresponding with the composition of mullite. Actually, when the qualities of the Corhart refractories were becoming established, certain Continental firms made experimental trials of fused fireclays, producing masses containing well developed crystals of various types, including mullite needles, but containing also a large proportion of vitreous material enclosing some cristobalite and tridymite crystals, which would have been unlikely to present any great resistance to the corrosive action of glasses and slags.

A sample of one of these fused fire clays promised to me did not arrive because of the outbreak of war in 1939. The porosity of this material was zero, or nearly so, and its low thermal shock resistance on this account would have rendered it useless in any case.

Use of Bauxite

Since alumina in excess of the proportion in mullite would lead to the formation of corundum in addition to mullite, bauxite clearly offered good promise as a raw material for making fusion cast refractories, and bauxite was tried at a very early stage in the experimental developments. Electric-arc melting would obviously be necessary to start the fusion, but to some extent the alkalis present as impurities in natural bauxite would provide the necessary conductivity when the mass had become sufficiently hot.

In the manufacture of Corhart "Standard," a good quality white bauxite is mixed with calcined refractory clay and sodium trisilicate in the amounts required to adjust the proportions of silica and alkali, the mixture being then calcined at 900°-1,000° C. in a rotating cylindrical furnace about 2 ft. 6 in. in diameter and 30 ft. long. The furnace is slightly inclined and is oil-fired from the discharging end.

The melting is carried out in a Heroult-type electric furnace which is in the form of a truncated cone, built of stout sheet steel; the flat bottom of the furnace is removable, but the top is open. The minimum depth is about 3 ft. but for the large production furnaces it is of the order of 5 ft. to 6 ft. or 6 ft. 6 in. About half-way up, on the front of the furnace, is a tap-hole and pouring spout. The mean diameter of the furnace may be as small as 2 ft. 6 in. to 3 ft. but, again, the production furnaces are considerably larger, ranging from about 5 ft. to 7 ft.

Furnace Operation

In starting up, the furnace is filled to the level of the spout with the calcined mixture already described. This bed is then covered with a thin layer of coke or carbon fragments, and graphite electrodes are lowered so that their lower ends rest in this coke layer (Fig. 1). When the power is switched on the whole of the layer becomes hot, due to multiple arcs between the coke fragments, and fresh bauxite mixture is added when the layer is glowing bright red, to cover the layer to a depth of some 15 in. During the initial arc-heating the bauxite mixture immediately above and below the coke is melted, forming a conducting mass which has a resistance of the order of only 1 ohm. per centimetre cube. When the coke layer has been burned out, therefore, the initial arc-heating is replaced by resistance-heating in this molten layer. The bauxite above the liquid becomes sintered together, forming a vault or domed arch which is heated by radiation from

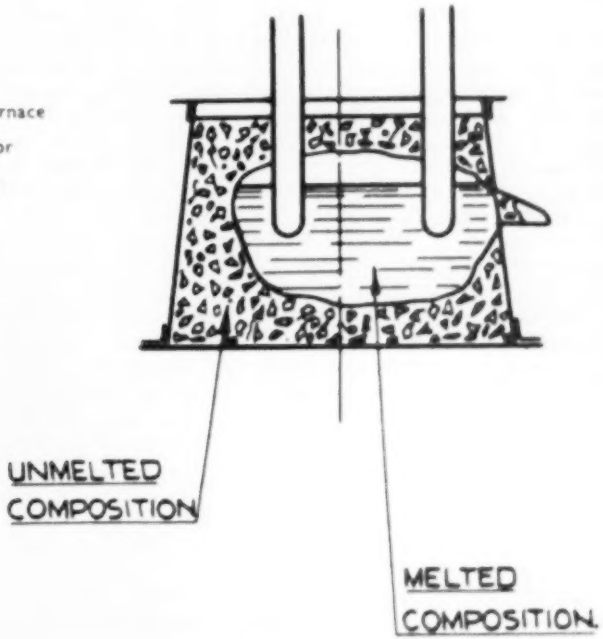


Fig. 2. Furnace ready for casting

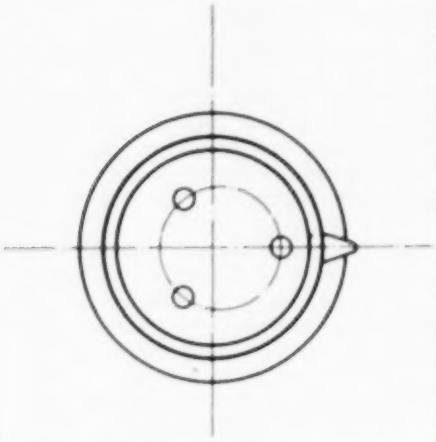


Fig. 3. Diagram to illustrate arrangement of electrodes

the incandescent liquid below, so that fused material trickles down from the undersurface, or semi-fused pieces fall from the vault into the pool as the melting operation proceeds (Fig. 2).

The furnaces are not lined with any form of refractory lining, the broken bauxite providing the necessary insulation between the molten mass and the casing. It is for this reason that the minimum size of furnace must be about 3 ft. in diameter and 3 ft. high. Actually a furnace of this size is just about large enough to allow a 6 in. cube to be cast. As, however, the thickness of insulation required is the same irrespective of the size of the furnace, the melting capacity increases very rapidly as the diameter and height of the steel shell are increased; a furnace 5 ft. in diameter is large enough to allow two blocks 12 in. by 12 in. by 8 in. to be cast at a time.

The production furnaces are mounted on short stiff trunnions, or on broad rockers resting on curved bearers. The graphite electrodes are from 6 in. to 8 in. in diameter according to the size of the furnace, and are mounted in a frame so that they swing over with the furnace as the latter is tilted during casting. Three electrodes are used, arranged at equal distances from each other, the centre of the system being displaced slightly forward of the centre of the furnace to ensure good melting near the spout (Fig 3). Three-phase current is used, the three electrodes being delta-connected. The interphase voltage is of the order of 120 volts, and the power input ranges between 700 and 1,000 kilowatts, according to the size of the furnace. Precise balancing of the three phases is virtually impossible, particularly when the furnace is being started up. During the normal running, however, the furnace operators can achieve and maintain a fairly close balance between the phases, by poking down colder bauxite from the top into one or other of the main current tracks.

Continuous Cyclic Operation

During melting, the level of the molten mass rises above the teem-hole but the liquid is retained due to the teem-hole becoming plugged with solidified material. When sufficient molten material has accumulated the power is switched off, the furnace is tilted backwards whilst the teem-hole is cleared by means of a crow-bar, and is then tilted forward into the pouring position. After the casting operation the furnace is brought to the vertical position and the current is switched on, more raw material being added as required. Sufficient molten material is reserved to ensure that the current starts again immediately, the cycle of operations being repeated continuously for many months when once the furnace has been started up.

The composition of Corhart Standard blocks is given as:— $Al_2O_3 >$ 70 per cent. SiO_2 18-22 per cent., TiO_2 3·5-4·5 per cent., Fe_2O_3 1-3 per cent., with ZrO_2, Na_2O and CaO with MgO present in amounts less than 1 per cent.

The fused mass is cast at a temperature of about 1,900° C. The

moulds are made of stout sheet iron, lined with slabs about 1¼ in. to 1½ in. thick, made of sand held together with linseed oil baked at a temperature of about 200° C. or with glue or other convenient adhesive. The mould is fitted with a wide "riser" which is filled to the top, to allow for shrinkage as crystallisation proceeds, and also to allow for thermal contraction whilst the main mass in the mould is still fluid (Fig. 4). Usually two moulds are filled at one pouring and the moulds are "topped-up" after a few seconds, the first mould being moved back under the pouring spout after the second has been filled, and the second mould then moved forward again to receive its second fill. In consequence of the shrinkage during cooling the upper portions of the Corhart blocks show voids which, though minimised by the use of the riser, and by topping-up of the moulds, may constitute between 10 per cent. and 15 per cent. of the total volume of the block (Fig. 5).

Cooling

The riser is broken away when the level of the liquid in it ceases to fall due to solidification of the material at the junction between the riser and the mould proper. The main mass of the block does not become completely solid for some hours, but the block is solid enough to be handled after some 15-20 min.; it is then transferred to a steel box in which it is embedded in kieselguhr to give some measure of annealing. The time required to cool to atmospheric temperature is approximately 5 days for Corhart tiles, and 10-12 days for blocks of the normal dimensions (12 in. by 12 in. by 8 in.) but is longer for thicker and larger blocks.

Perhaps that is sufficient about the actual process of manufacture. The resulting block consists mainly of crystals of corundum and mullite, mostly less than 1 mm. in their longest dimension, with some 30 per cent. of glassy matrix containing a high proportion of alumina. The

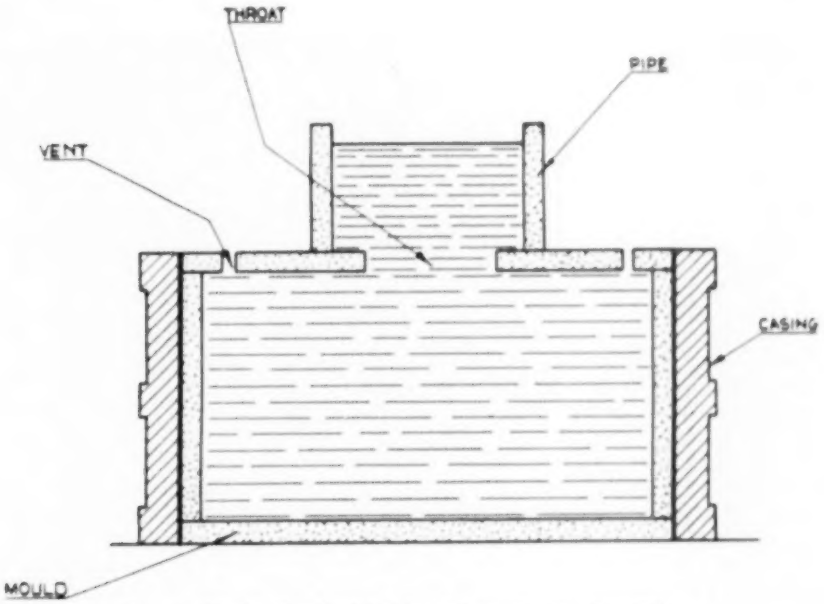


Fig. 4. Mould, fitted with "riser," immediately after filling

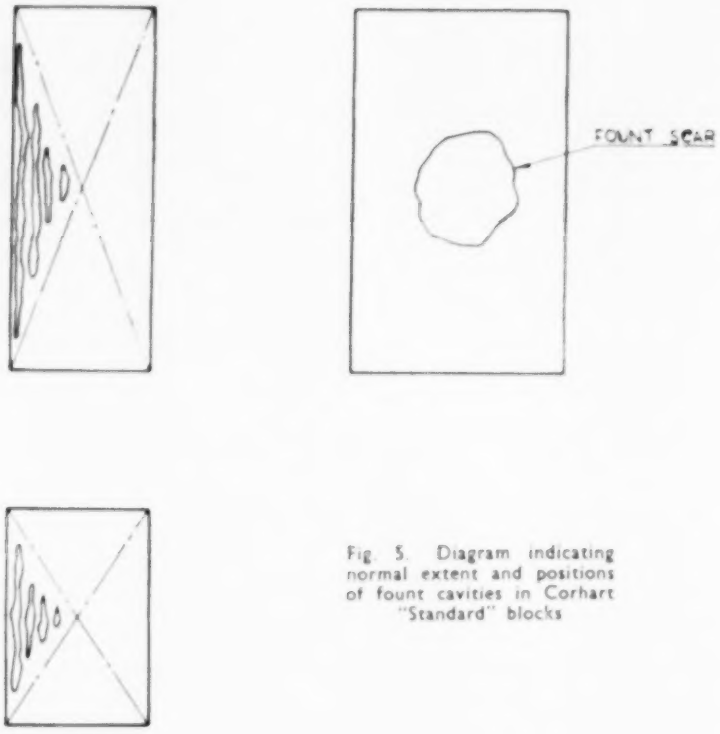


Fig. 5. Diagram indicating normal extent and positions of fount cavities in Corhart "Standard" blocks

softening point of this glass is in the region of 1,300° C. and its viscosity at the temperatures used in the melting of most commercial glasses (1,400° C. to 1,540° C.) is very high; as a result it is dissolved out of the block only very slowly. If a Corhart block is maintained at a high temperature for sufficient time to allow the glassy matrix to drain away, or if the glassy matrix is leached out in the cold with hydrofluoric acid, the mullite and corundum crystals are found to be well interlocked, so that they cannot readily become detached from the block surface.

For blocks to be used in glass manufacture this is a matter of first importance, since detached crystals of mullite or of corundum would not readily go into solution in the glass, and there would be considerable risk of individual crystals being carried forward in the glass, to appear as "stones" in the finished article. This is, of course, not unknown, but as compared with the number of stones found in glass made in tanks constructed of most types of fire clay blocks, the number found in glass melted in Corhart tanks is very small.

Larger pieces of Corhart, which may break away as the result of mechanical damage or "spalling," usually sink through the glass sufficiently rapidly to be carried down to the tank bottom, where they are quite harmless. Pieces of fire clay refractories, on the other hand, will float on the surface and are carried forward in the glass stream to appear in the finished glass.

(To be continued.)

A DIPPER'S DRYER

INCREASING demands for pottery ware have created a need for drying plant of higher efficiency, but its installation is made difficult in some of the older factories because of limited space.

The drying of glaze-dipped, biscuited ware demands a different technique from that employed in the drying of unfired materials. There are fewer snags, and these usually relate to factory layout rather than to such problems as the speedy drying of ware without distortion.

Workrooms, cupboards and stoves of various kinds have all been used in the drying of dipped ware, but on grounds of flexibility and economy these have given place in many factories to such compact units as the Casburt dipper's dryer which is illustrated.

No Structural Alterations

It is often more conducive to an even flow of work for dippers' dryers to be interposed at suitable places in the production line. In this way space may often be saved and ware, after rubbing, may be placed for further firing with the minimum of handling. An advantage claimed for the Casburt unit is that it requires no structural alterations in its installation and it can easily be re-sited if this be demanded by changes in factory layout.

As will be seen, the dryer is self-contained. It consists of an outer shell with a shelved and partitioned interior section, the latter rotating on a central vertical spindle. The shelves are adjustable, thus allowing for variations in the height of the ware to be dried. Full insulation of the dryer body is standard, and an arrangement of rubber seals at loading and unloading points prevents the blowing of heated air on to the operator—which refinements make for comfortable working, high output, and the fullest use of heat input.

Dipping tea ware in glaze

Shelving glazed tea ware in dryer

At the loading point trays of glaze-dipped ware are shelved before passing round the dryer to the adjoining unloading section, whence the dried ware is removed for rubbing and placing. A humidity stage is provided, moist air being delivered in required volume to the newly placed ware via a by-pass in the exhaust, by means of a recirculating fan, whilst heating is by low pressure steam.

The standard unit fits a square 7 ft. by 7 ft., the minimum ceiling being 8 ft. 6 in.; and larger models can be built if required.

Given a regular supply of steam at suitable pressure, together with the necessary steady flow of ware, it is stated that 800 to 1,000 dozen average "tea" ware can be dried per day of 8 hours.

This dipper's dryer is designed and built by Casburt Ltd., Park Road, Fenton, Stoke-on-Trent.

MAURICE SOLOMON RETIRES

THE announcement that Mr. Maurice Solomon, F.C.G.I., M.I.E.E., is retiring from the Board of The General Electric Co. Ltd., on account of continued ill-health, will be received with regret by a large number of friends of the older generation in the G.E.C. and the electrical industry.

Mr. Solomon was a scholar of St. Paul's from which he obtained a Clothworkers' scholarship to enter the City and Guilds Central Technical College.

After a short period with Johnson Matthey and Co. and the Nernst Lamp Co., during which he met the late Lord Hirst, then Mr. Hirst, he joined The General Electric Co. Ltd., in 1903 to work in the experimental department of the Robertson Lamp Works. In 1904 he was transferred to Witton as works manager of the Carbon Works, and became general manager of these works at the end of the following year.

Mr. Solomon was appointed a director of the G.E.C. in 1915 and in 1920 became managing director of Pirelli-General Cable Works Ltd., a post which he held till 1928 when he relinquished it but remained on the board. He took a very active interest in the affairs of the Cable Makers' Association and was elected chairman in both 1929 and 1936.

Following up his early success in the I.E.E., he read a paper on "Yellow Flame Carbons" in 1912, for which he was awarded an extra premium.

The ceramic thickness gauge recently developed by the U.S. National Bureau of Standards

CERAMIC THICKNESS GAUGE

AN electronic thickness gauge for measuring the thickness of nonconducting coating on nonmagnetic metals has recently been developed by Charles C. Gordon and Joseph C. Richmond in a project at the U.S. National Bureau of Standards sponsored by the U.S. National Advisory Committee for Aeronautics. The new instrument provides a simple, direct, non-destructive measurement. These measurements have become important with the increasing use of ceramic materials as protective coatings for metals and alloys in high temperature service. The new electronic gauge can be used with nonmagnetic high-temperature alloys on which magnetic thickness gauge cannot be used.

Details of Instrument

The instrument consists essentially of a small probe coil, an inductance indicating system, and a device for positioning the coil and measuring its distance from the test surface. The probe coil is housed in a cylindrical test head. A small plastic rod attached to a dial indicator extends axially through the coil to serve as a feeler element. The test head is mounted in a heavy gauge stand which provides for controlled movement of the test specimen with respect to the probe coil. The electronic components of the 500 kc. oscillator and the bridge-type inductance indicating system are housed in a small cabinet and connected to the test head by a removable shielded cable. Bridge balance is indicated by a sensitive galvanometer.

The measurement is based upon the change in inductance of the probe coil due to the proximity of the coated metal surface. This

change may be visualised by considering the combination as a transformer with the probe coil as a primary coupled to the metal surface as a short-circuited secondary. The inductance of the primary varies with this coupling, and hence with the proximity of the metal surface.

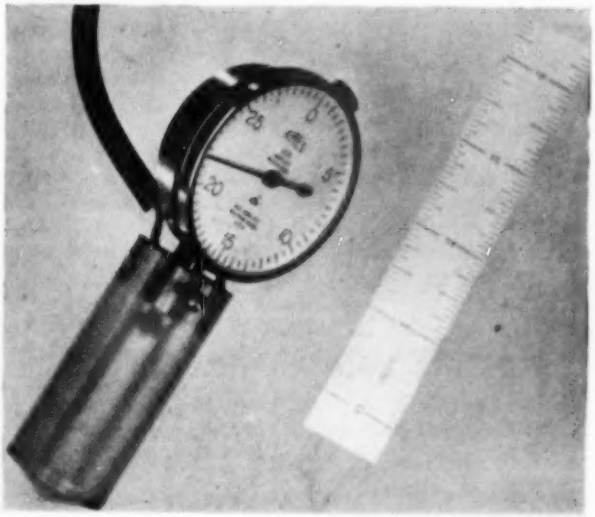
The instrument thus relies on the maintenance of a fixed distance between the probe coil and the metal surface whether the ceramic coating is present or not. The coating material has a negligible effect on the electric field at the frequency used; the metal surfaces are similar so that their electrical properties are nearly identical. Under these conditions, if the inductance of the probe coil is the same in both cases, the separation distances will be equal and the dial gauge reading will give an accurate value for the coating thickness.

Coatings up to 0·090 in. Thick

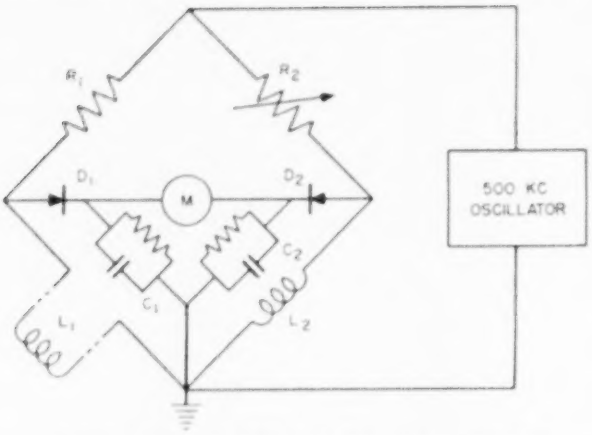
The ceramic thickness gauge is designed to measure coating up to 0·090 in. thick. For thin coatings, where the coil is within 0·020 in. of the metal surface, the sensitivity of the inductance bridge is about the same as the reproducibility of the mechanical dial gauge reading. In this case, the thickness indicated on the dial gauge is correct to within about 0·0002 in. When the coil is 0·10 in. from the metal surface, readings may, however, be in error by as much as 0·001 in.

Before a thickness measurement is made, the instrument is calibrated on an uncoated specimen identical in size, shape and composition with the coated specimen to be tested. The reference specimen is placed on the table of the gauge stand and the table is raised until the feeler of the dial gauge is in positive contact with the surface. The dial gauge is then set at zero and the bridge rheostats are adjusted so that the galvanometer is zeroed. The inductance of the probe coil in the presence of the uncoated metal specimen is thus established as a reference value. The table is lowered and the uncoated specimen replaced by a coated specimen. The table is again raised until the galvanometer reads zero. The thickness of the coating is then given directly by the dial gauge reading.

Independent tests have indicated that variations in the size and shape between the coated and uncoated



The probe coil is housed in a cylindrical plastic test head. A small plastic rod attached to a dial indicator extends axially through the coil to serve as a feeder element



Simplified schematic diagram of the inductance balance indicator

INDUCTANCE BALANCE INDICATOR FOR CERAMIC THICKNESS GAGE

specimens are not important unless the thickness of either is less than 0·025 in., the minimum width of either is less than 0·5 in., or the measurement is made within 0·25 in. of an edge. For accurate measurements on curved specimens it is necessary that both reference and test specimens have the same curvature. It was also found that certain metals, which are themselves nonmagnetic or only weakly magnetic, produce magnetic scales when oxidised. The presence of any magnetic material in the coating or at the coating-metal interface will make accurate measurements impossible.

Impedance Bridge

The impedance bridge used in this instrument is particularly suitable since variations in the inductance of the probe coil are indicated without separate balancing of resistive and reactive components at the bridge voltage. This is an advantage in thickness measurements because reactance variations are usually much larger than the accompanying resistance variations.

The bridge circuit is energised by a 500 kilocycle oscillator employing a dual triode in push-pull. A peak reading rectifier circuit, consisting of a crystal diode in series with a capacitor and resistor in parallel, is connected across the probe coil. The D.C. voltage appearing across the capacitor is essentially equal to the peak A.C. voltage drop across the probe coil and, since the probe coil current is determined principally by a large series resistance, this voltage is effectively proportional to the inductance of the probe coil. In order to obtain a comparison voltage with the same sources of extraneous variation as the probe voltage a reference coil is arranged in a similar circuit and fed from the same oscillator through a variable resistance which may be adjusted to equalise the A.C. voltage drops for both coils. The sensitive galvanometer, protected against overload by two crystal diodes in shunt opposition across the meter, indicates any unbalance between these two branches of the bridge.

Although this instrument was developed primarily for the measurement of the thickness of ceramic coatings on turbine blades and other high-temperature parts of aircraft power plants, it should be useful for thickness determinations of paint, plastic and other non-conducting films on aluminium, brass, copper, stainless steel and other slightly nonmagnetic metals.

MINOAN FIGURINES

by

IREEN JAMESON

THE idea that Greek civilisation and culture arose in a couple of centuries out of nothingness to the heights of the Parthenon and the beautiful and delicate pottery, has long since been dispelled. The beginnings of every art, and that includes pottery, are a long and stumbling process, and only gain momentum when a considerable degree of proficiency has been attained. Any decline is then generally rapid.

This is illustrated admirably by Minoan figurines. Far too little is yet known of the history of pre-Hellenic Crete, nor will it be possible to tell "many a tale" until the written material available has been deciphered. But, until such time, there are the buildings and objects found in archæological excavations.

Fig. 1. An example of "Neolithic" figurines

Fig. 2. Early Minoan I shows the face receiving more attention

The potter must always be proud that it is clay products that have so greatly helped in elucidating the lives of peoples long past.

Close Link With Religion

In ancient Crete, though pottery was employed later than the working of stone, it was already practised near the beginning of what is called the Neolithic period (4,200-3,000

Fig. 3. Female figurine of Middle Minoan I, showing the effect of more detailed work in the bell-shaped skirt and "Elizabethan" collar

B.C.).* The large numbers of figurines made, are closely linked with the prevailing religious beliefs and so we have mainly small models of the all-embracing, all-powerful Mother Goddess, who ruled life and death. She was the Ruler of Nature and was first worshipped in forests and then in pillared chapels. She was the Lady of Wild Life. In combination with the many figurines of this "one and only" Goddess, are wild and domestic animals, the air is represented by doves, water by flying fish and the underworld by snakes twined round her arms.

For the convenience of archæologists the true "Minoan" age has been divided into Early, Middle and Late Minoan with numbered subdivisions. These periods were preceded by Neolithic development (of another people) and followed by decay after repeated conquests from the mainland.

Neolithic "figurines" were about 2-3 in. high, flat and fiddle-shaped, for the most part too crude to show if female or not. However, towards the end of that period some modellers had become sufficiently familiar with their material to venture into the making of rather stumpy, steatopygous figures, dis-

* All dates given are approximate and may have to be revised in the light of new material.

tinctly female and most of them wearing no clothes (Fig. 1). Occasionally clothes were indicated by incisions filled with white or red.

Attention to Face

By Early Minoan I times (3,000-2,800 B.C.), it was the face of the figurines that was receiving attention and for the first time ears were added (Fig. 2). Here too, appeared the "boy," son of the Mother Goddess, a subsidiary figure representing spring. The material used was extremely coarse and though obviously care was taken in modelling, the surface remained very porous and not pleasing because of the dirty grey colour. The true "Minoans" had infiltrated slowly into Crete, settling near the centre of the island and most finds of early ware are fairly close to each other. If these people brought with them similar religious and artistic traditions or intermingled with the Neolithic peoples is impossible to tell, but there was no distinct break and figurines continue for the most part to be columnar with short, stumpy arms, made of terra-cotta.

Towards the end of Early Minoan II (2,800-2,500 B.C.), it is true, a pinkish slip was sometimes employed and decorated preferably in dark, but this work was still very rudimentary. However, the potter's art progressed and he learnt that firing influenced the appearance of the ware so that "mottling" became all the rage. Where whole vases were concerned this was not so difficult, but as fashion decreed "mottled" pottery, difficulties arose where only the skirts of the figurines, but not the upper part of the body were so treated. By 2,400 B.C. this fire mottling was being faked, parts of the ware being suitably daubed or painted before firing.

More Correct Proportion

In Early Minoan III (2,500-2,200 B.C.), figurines had become much more recognisable. The females, with a wider base to represent a skirt, were obviously the Mother Goddess and correspondingly larger, increasing up to 5 in., while the males, perhaps votaries, remained more undeveloped and smaller. Arms and hands, too, began to take on more correct proportions, although throughout the Minoans had difficulty with the length of the arm. It was not yet found practicable to free the arms from the body, but the hands were clasped over the chest instead of hugging their stomachs.

Preparation of the raw material had greatly advanced and the red terra-cotta was of a much finer texture, permitting the use of decoration in black, red and white and for the first time all three were success-

Fig. 4. An example of the work produced at Knossos

Fig. 5. Flying fish were used to illustrate supremacy over air and water

fully combined. A most interesting piece of this period is a "toby jug" with a decorated skirt and turban-like head-gear.

Actually the figures were at all times dressed in the prevailing fashion and in the later "Palace" period when refinements lead to frequent changes, it is almost possible to date figurines within a year or so.

Attempts at Glazing

With the beginning of the Middle Minoan period (2,200 B.C.), the potter really came into his own. Up to that time clay figurines, vases, bowls, etc., had been based on a tradition of working in stone, leather and basket work. Now free modelling became the rule rather than the exception. Raw materials were ground and washed much finer with the resultant denser texture. As Middle Minoan I (2,200-2,050 B.C.) advanced, more and more attention was paid to detail. The female figurines, stretching out their arms, had bell-shaped skirts, with open-fronted bodices and stiff "Elizabethan" collars (Fig. 3). The male figurines had a small loin cloth and the very characteristic belts showing their slim waists. Votive offerings became numerous and there are miniature goats, dogs and even tortoises, while separate limbs, often with a hole for suspension near the shrine were left by the ailing. Decoration and material became diversified and light, almost ocre, terra-cotta and a body of a dark full red colour were used. The first attempts at glazing appear. Initially this was not very successful as the glaze was apt to soak into the porous body leaving a somewhat pitted surface, but evidently experiments continued because soon the potteries round Knossos were producing almost perfect ware.

One further example worth mentioning from this period is a most delightful bowl, around the rim of which are sitting tiny figures modelled in the round. Unfortunately they have broken at the waist but judging from the lower half only, the human form had now been mastered in the medium of clay.

Two Main Centres

All this time settlements had been established, abandoned, moved or enlarged. There were two main

centres, both inland, and the most famous of these is Knossos. Here a palace arose, was partly demolished to make way for a bigger and better edifice and continued to receive additions for a couple of centuries. This palace was not only a Royal residence, but also the centre of government, the national treasury, the centre of religious festivals, of art and trade, and acted as a powerful local stimulus. Why the large artistic output of Knossos was only for use in the immediate vicinity and not for export we do not yet know, but if we think of Minoan figurines it is these products that spring to our mind's eye (Fig.4).

The convention of white skin for the ladies and a darker reddish hue for the men was perfected with good glazes. The Goddess wore skirts with flounces and ruffles. Her open-fronted bodice was held in by a tight belt accentuating the wasp-waist. Delicately painted flowers and designs indicate that the ladies of the day were fond of embroidery and the variety of head-wear show that milliners must have had plenty to do.

Let us imagine a shrine of the Mother Goddess. Not for the Minoans, vast, imposing figures. A pillared hall at the end of which on a raised platform a pillared hall in miniature, the whole not more than 2 ft. high, representing a forest. In the middle of this the figurine of the Goddess holding the snakes of Death. By her side stands her son to indicate new life and the spring, while over her head are suspended doves and flying fish (Fig. 5) to show her supremacy over air and water. The whole model of clay, painted brightly and covered with an excellent glaze (although the white is apt to have a greenish tinge). Below the platform a clay bench for the reception of votive offerings.

Close Secret

This rapid flowering of the arts came to a sudden end. The first (historical) earthquake shook the island. Though neither Knossos nor any of the other towns were destroyed it had a disastrous effect on the potter. Late Minoan (I 1,580-1,500, II 1,500-1,405 B.C.) continued to be highly productive in quantity. Palace life was rapidly revived and the buildings even further extended, but the art of fine modelling in clay was lost. As the knowledge of glazing disappeared with the first earthquake we must assume that it had been kept a closely guarded secret and that the few initiated had perished. Figurines grew primitive, although different

Fig. 6. More primitive figurine produced after the first earthquake

from the early (Neolithic) style (Fig. 6).

After a second severe earthquake in 1,405 B.C. when the whole of Crete tilted by several degrees and one end of the island submerged, the population scattered. Soon wave after wave of invasions from the mainland brought a new religion with its multiplicity of gods and with the old beliefs in the universal goddess the art of making figurines was driven underground and decayed.

SCOTTISH CERAMIC INDUSTRY

The Problem of Home Supplies

THE continued demand for merchandise in the export field is creating a problem for buyers of ceramics at home. Scottish store buyers, back from a circuit of Scottish and English suppliers have indicated that the trend will be rather towards deterioration of supplies than towards improved deliveries.

The average retail buyer anticipated a collapse of the export market long before now, and anticipated that the unwanted ware would be available at home, by this year at least. That expectation has not been realised and even the dregs of the export trade are not coming now, as they did a year ago, to the home retailer.

The net effect of this situation is a definitely pessimistic tone in the retail trade. The fact that white and self-coloured ware is available in fairly ample volume is not in any way a consolation. The demand is essentially for decorated ware and the money is still there, despite all the current talk of scarcity of cash, if the merchandise can be provided.

Two and a Half Years' Delivery

One example of export activity has been cited by a Glasgow buyer. Visiting New Zealand with the firm's range, a representative began his tour quoting 6 months delivery. After only 2 weeks and with much pruning of offered business he was quoting 2½ years. In effect this means that output from this source is tied up for 2½ years, always accepting the possibility that the market may collapse unexpectedly in the interval. Failing such a development the prospect of any supplies from this source—and similarly placed firms, is limited in the extreme.

Plaster Ornaments

One result of the shortage of pottery in Scotland has been a boom in the sales of plaster plaques, figurines and similar ornaments. Many of them are crude in the extreme, in colour; the moulding of even the worst is better than the colouring.

Latterly there has been a swing away from this very crude type of ware to a much more delicate, and magnificently modelled range of plaster ware. The sellers claim that it is a fired plaster and vastly superior to the cruder raw-coloured models originally sold (and which were liable to crumble in damp). The newer type is clearly the work of competent artists, has a varnished glaze and some delicate colour, without any real attempt to suggest actual colour details, or to completely colour the model.

The cost of such figurines is perhaps 10s. as against the £5 payable for a pottery figure. At that price it represents an attractive "buy" for the houseproud woman who is deprived of better ware. Actually it has little interest to the ceramic craftsmen beyond the fact that it is presently usurping a home market from which the quality firms are banned.

Tourist Trade

The tourist trade in Scotland has provided a great deal of business this year for the stoneware industry, and particularly for small low priced objects with a distinctively Scottish flavour. A typical example of this type of work is the range of stoneware scent bottles used by one Scottish firm (and made in Glasgow).

These proved tremendously successful with tourists in many centres over the summer and emphasise the value of co-operation between allied interests in devising such gift lines. There is plenty of scope for development of this trade if time and effort can be spared from other lines which are selling equally well, and next year there is a prospect that stoneware will be featured even more strongly in the tourist centres. What

was particularly interesting in the example quoted was the fact that it was Scottish without being maudlingly or theatrically so.

There has also been a fairly strong show of stoneware from Portobello in the overseas shops and gift shops, concentrating on servicing visitors to this country. This "Thistle" ware has achieved a definite distinction since the end of the war permitted revival of decorated ware, and is now in steady demand among collectors and shoppers who appreciate quality.

BRICK, TILE AND GENERAL CLAYWORKING MACHINERY

AN interesting brochure C.W.M.3 has been received from Wm. Johnson and Sons (Leeds) Ltd., Castleton Foundry, Armley, Leeds 12.

This brochure covers modern plant for the production of ordinary bricks dependent upon the plastic, wire-cut, stiff-plastic or semi-dry processes. Speciality production machinery for concrete or lime sand bricks as well as for refractories are also mentioned.

Included in the illustrations are brick-making plants, automatic feeders, crushing rolls, high-speed rolls, edge runners, mixers and pugmills. Cutting off tables, brick, tile and pipe making machines operated by hand power as well as power are included. Power - driven vertical brick, tile and pipe machines and brick and tile presses are described. Hand-screw presses and friction-driven presses are mentioned as well as perforated grinding mills, a toggle brick making and pressing machine, a road mill and a revolving table brick press.

To those interested in brick and tile making, blast furnaces, collieries, cement works, gas manufacture, slate quarries and foundries, Wm. Johnson and Sons (Leeds) Ltd., are always prepared to offer specialised machinery. The brick-work machinery was first made as early as 1860, so that in 90 years the firm has been able to gather a wealth of general information relating to such plant.

The Ketton Portland Cement Co. Ltd. —The Directors of the Ketton Portland Cement Co. Ltd., in presenting their twenty-second annual report and accounts for the year ended 30th June, 1950, state that the profit for the year after providing for taxation amounts to £71,332.

Impressions of an American Visit

by SIR FRANCIS JOSEPH, Bart.

A "CERAMICS" Report

IMPRESSIONS of a recent visit which he paid to the U.S.A. and Canada were given by Sir Francis Joseph, Bart., the well-known North Staffordshire industrialist, in an address to members of the British Pottery Managers' and Officials' Association, at Stoke-on-Trent.

Mr. Cuthbert Bailey (Doulton and Co. Ltd.) presided.

Sir Francis said he went to America and Canada as a common man trying to meet and study the common men of the Western hemisphere. He was of necessity limited in that aim by the vastness of the American continent, but he had, none the less, formed very definite conclusions of the inter-dependence of American and British national interests.

Questions on Marshall Aid

"I did not go to the U.S.A. as a politician," went on Sir Francis: "I am not a politician. I went to tell the American people, in lectures and speeches, what we in Britain had done during and after the war, and to invite their frank opinion on our efforts. I found the American people strangely sober in their outlook and most anxious to get the latest and fullest facts available on which to form a mature judgment and appreciation of our position and our prospects. The U.S.A., I found, was scratching its head to know what we were doing. They had offered Marshall Aid in the expectation that it would enable Europe and Britain to achieve economic recovery.

"Their attitude now is: 'Is Britain taking Marshall Aid for granted by reducing working hours and improving social services at the expense of American taxpayers?' They also ask the question: 'Does Britain want to live on easy-street through Marshall Aid?' Even the wealthier classes put forward these points. I told them the story of our efforts, sacrifices, suffering and ordeals over the past 10 years. I told the Americans we had to embark on measures of social reform or face the possibility of revolution. I emphasised the inter-dependence of nation with nation as the only means of securing world recovery, and the need to combat the false doctrines of Communism with a faith linked to Christian principles.

Abandoned Isolationism

"The gigantic change in the financial structure of Europe, plus present American national affluence, has placed the U.S.A. in a remarkable position. They are using that position wisely and well, and already one is glad to see, the Old World is on the road to ordered progress. The last American barriers to full friendship with Britain are gone. They have abandoned isolationalism. The service which the U.S.A. has rendered to mankind since 1945 has revived the old League of Nations principles, and encouraged free nations to accept the challenge against their way of life."

Sir Francis said that America is facing up boldly to their tremendous

responsibilities as a nation. He had been particularly impressed to see and meet the youth of the U.S.A. They were deeply aware of their duties to democracy, and showed a ready appreciation of the new rôle which America had been called on to fill in world affairs.

"If the young people of Britain show the same spirit of patriotism that emanates American youth today we shall continue to have our place in the sun," added Sir Francis.

He went on: —

Meet the People

"One of England's most vital needs at the moment is for a more personal knowledge of the people of the United States. One thing is certain; the oftener we meet one another the better it will be for ourselves and the world. We must always bear in mind that inventions in marine engineering have narrowed the distance which separates our two nations, whilst the progressive science of aviation has done much to make us nearer neighbours and firmer friends.

Titanic Task

"Two world wars have united us in spirit. Common ideals have joined us together to preach peace on earth and goodwill to all mankind. Each nation needs the other. Business worries often lead to political misunderstanding but let us never forget that the other's point of view may be sometimes right. Differences cannot always be cleared up by correspondence. It is personal contact which removes friction. That is the best lubricant. The commercial traveller oftentimes does more good in solving problems between nations than statesmen or official delegations. The business man supplies the oil which makes the wheels go round.

"This proves how great is the debt we owe to the younger generation of the potters of North Staffordshire and the men of Birmingham and the Midlands in the motor and engineering industries who have blazed the trail from East to West of the U.S.A. and created such an increased demand for British goods by reason of quality, design and value that the dollar gap is vanishing like morning mists. Britain's example and efforts since the war have won the respect of the American continent. The U.S.A. accepts our effort as inconvertible proof that we will only accept help until we have repaired the ravages of war. We know it has been a titanic task and yet to be completed, but once again it demonstrates the truth of Pitt's arresting phrase 'We have saved England by our exertions and the world by our example.'

"We banish the fear that the U.S.A. seeks our friendship only to win a mean advantage for herself. Our mutual friendship is based on common ideals, a profound faith in Divine Guidance and the firm conviction that our way of life can only be maintained by our co-operation and unity. Freedom and human liberty are a common heritage to both nations. Best of all they are shared and firmly held by the British Commonwealth. These facts add such strength to our unity that even the most gigantic combination of powers which seek to undermine it must realise the hopelessness of their evil intentions.

Just and Equitable Tariffs

"We both increasingly recognise the interdependence of nation with nation. The vast resources both of U.S.A. and Canada and their freedom from the physical destruction of their factories and homes, which levied so great a burden upon us, have created the will to give their financial and moral aid both to us and Western Europe and all nations of goodwill.

"That there will be difficult hurdles to surmount is certain. The conference at Torquay is trying to

give each nation its place in world trade by evolving a fair and reasonable scheme of just and equitable tariffs. This is an immense task. On the one hand we have to bear in mind the independent yet inter-locking needs of every country in what is termed the sterling area. On the other hand is the difficult problem of American tariffs to be considered and adjusted. Today, Canada has taken a bold step both for herself and the world by freeing the Canadian dollar from control. What effect this will have on the exchanges of the world has yet to be determined.

"The potentialities of our friendship open a vista which may result in increasing the happiness and well-being of mankind. We are joined in a great adventure. Britain is playing a great part which we believe will win for us a place in world affairs worthy of our long and honourable history, and for the U.S.A. a prestige to which we gladly pay tribute and admiration.

"Let us then boldly march forward together so that mankind can reach the Land of Promise."

DISCUSSION

Arising out of the discussion, Sir Francis was asked whether the quality of British goods was too high for the average American housewife, who was said to prefer changes rather than a long-lasting article.

He replied that the lesson for British manufacturers, as he saw it, was to maintain quality production for America. He thought they would by that means maintain their general custom in the U.S.A., even when markets were less open than today.

Sir Francis added that he had come across very little American-made pottery tableware that could compare in any way with British products. He had also seen little British pottery in America, having regard to the vast field open there to our ware.

Further questions were: What is the percentage of British products being sold in America in relation to dollars received? and, Are we apt to regard the U.S.A. as being centred in New York, and to concentrate on the New York market to the exclusion of other commercial centres?

Sir Francis said that American purchasing power was at present sky-high, and he regarded U.S.A. purchasing power per head of the population as the highest in the world. The American market was almost limitless, and he considered personal contact was the master move for selling British products in the U.S.A.

Cost of Living

Questioned as to the comparative cost of living standards for the average British and American family, Sir Francis said that living costs were constantly rising in the U.S.A. The American housewife was far more affected on this account than the British housewife.

On the subject of Marshall Aid, Sir Francis added that American public opinion was satisfied that the scheme was fundamentally sound, and had served an effective purpose. Britain's recovery, in the face of great difficulties, had helped to stabilise U.S.A. opinion on that point.

METAMIC

THE Morgan Crucible Co. Ltd., have recently developed materials described as metal-ceramic, under the registered trade-mark "Metamic."

There is a growing need for materials operating at high temperatures. Conventional ceramics often fail for strength, creep resistance or thermal shock.

The intimate association of metals and ceramics offer virtually a new class of material. Numerous combinations show that the resultant product can be tailor-made to resist oxidation, corrosion, creep, etc.

(Continued from CERAMICS, September, 1950)

Moulded Refractory Burners and Tunnels for Industrial Purposes

by

W. N. SMIRLES, B.Sc., A.R.I.C., M.Inst. Gas E.

Development Officer, Industrial Department West Midlands Gas Board, Birmingham District

TO make the most efficient entraining device for a high velocity burner the following size relations must hold:

Tunnel length in. × ½ in. = tunnel base (sq./in.).
Tunnel base (sq./in.) /6·8 = slot area (sq./in.).
Slot area × 0·45 = venturi area giving venturi dia. D.
D./1·1 = air jet diameter.

If a low velocity burner is being made, then a proprietary make of injector approximating to the above, may be fitted.

Velocity and Tunnel Shape

1. *Heat Transfer Tests*

In the early stages of the development of this burner we had little to guide us in the matter of optimum tunnel shape. The object of the burner being at times to use the greatest velocity locally, it was realised that we could effect this by making the tunnel more convergent but quantitative measurement of the effects produced was not forthcoming until we adopted the simple technique of using a water cooled tube across the burner mouth as an index of heat transfer.

The tube used for these tests was of polished heat resisting steel 0·126 in. outside diameter and ⅛ in. inside diameter. A suitable length of this was soldered into two brass bushes which could be screwed into ½ in. tee pieces with accommodation for a suitable accurate thermometer and appropriate connections for water inlet and outlet. The inlet was connected to a constant head tank and the flow of 1 lb. per minute gave a suitable temperature rise with all burners. It was established first of all that within reasonable distance of the burner mouth consistent results of heat transfer could be registered. Thus with a 2 in. × ¼ in. slot burner working at 48 c. ft. per hour, the following data were observed:—

Distance of tube above burner mouth	¼	½	¾	1	1½	2
Heat transfer. B.Th.U. per hr. registered	1,550	1,555	1,550	1,450	1,340	1,175

In all tests, however, the distance from the burner mouth was standardised at ½ in.

2. *Heat Transfer—Calculation of Convected Heat*

The fact that the burner orifice is ideally suited to heating a tube, is of great importance because it enables us to calculate the amount of heat transferred by forced convection during any test. The total quantity of heat transfer (convection and radiation) being accurately determined the radiant heat transfer follows by difference.

A great deal of work has been performed on the heating of circular section tubes in streams of hot fluids (liquids and gases) and all the data for widely differing conditions of temperature difference, tube diameter, velocity of fluid and fluid characteristics can be related to each other by an expression of the form

$$\frac{k\theta}{Hd}\Big/\frac{(c\mu)}{(k)}^{0\cdot3} = \frac{(dv)}{(\mu)}^{0\cdot6}$$

This applies to high velocity streams where $\frac{(dv)}{(\mu)}$ the Reynolds number has a magnitude greater than 1,000.

In this formula the symbols represent:—

h = heat transfer in B.Th.U. per sq. ft. of tube surface per hour.
d = tube diameter (feet).
θ = temperature difference between fluid and tube °F.
v = mass velocity, i.e. lb. fluid per hour per sq. ft. of burner aperture.
c = specific heat at constant volume.
μ = viscosity of fluid.
k = thermal conductivity of fluid.

$c\mu$ and k are obtained from standard data on gases and the value of $\frac{c\mu}{k}$ which appears in the formula is taken as constant at all temperatures. These data are obtained for the mean temperature of the film between fluid and solid.

The mass velocity of the fluid is obtained from the gas rate, theoretical air requirement and burner orifice. For a calculation of h therefore, it is necessary to determine the flame temperature or assume a reasonable value for same. The determination not being possible it was decided to adopt a figure of 1,850° C. for the flame temperature. Recent results by Leason‡ working with similar types of converging tunnels indicated flame temperature of this order. In the event of this temperature being say 100° C. too high, then the error introduced with a calculation of convection to a tube at 30° C. would be approximately 6 per cent.

3. *Application of the Foregoing to Tunnel Design*

In our early work on this type of burner we had remarked on its curious behaviour with increasing mixture feed. Thus a burner working at a low air pressure of ½ lb. per sq. in. would have the tunnel walls at a temperature of perhaps 1,250°, but on increasing the air pressure and gas consumption to retain calyx conditions the temperature of the tunnel fell and finally became relatively cold. Reference to Section 1, Table 1, illustrates this.

Our first application of heat transfer measurement was to determine the cause of this and a series of tests were performed with a 2 in. × ⅛ in. slot burner of which the grid had 11 slots ½ in. × ·025 in. The heat transfer performance is set out in Table 1, Section 1, and graphically in Fig. 1

‡ Leason. University of Leeds Library. Private Communication.

TABLE 3

HEATING PERFORMANCE OF SLOT BURNERS

Burner	*Grid Slots*	*Gas Rate C. ft. per. hr.*	*Heat Transfer Observed B.Th.U. per sq. ft. per. hr. (Thous.)*	*Heat Transfer Corrected Calculated B.Th.U. per. sq. ft. /hr. (Thous.)*	*Heat Radiated B.Th.U. per. sq. ft. per. hr. diff. (Thous.)*	*% of Total heat radiated*	*Tunnel wall Temperature °C.*
SECTION 1							
1 in. long tunnel taper ½ in. to ·142 in. curve A.	0·5 in. × ·025 in.	50	215	155	60	28	1,240
		50	282	199	83	29·4	1,290
		63	315	224	91	28·8	1,250
		78	345	238	107	31·0	1,180
		96	363	270	93	25·6	1,080
		112	356	296	60	16·9	patchy
		138	358	335	23	6·4	..
		174	360	385	25	—	cool
SECTION 2							
1 in. long tunnel taper ½ in. to ·264 in. curve D.	0·5 in. × ·017 in.	40	200	125	75	37·5	1,160
		58	242	155	87	36	1,260
		81	287	186	101	35·2	1,310
		111	345	218	127	36·8	1,260
		135	386	228	158	40·9	1,260
		155	417	248	169	40·5	1,200
		175	435	266	167	38·6	—
SECTION 3							
1½ in. long tunnel taper ½ in. to ·016 in. curve E.	0·5 in. × ·017 in.	36	222	160	62	28·0	1,240
		54	282	194	88	31·2	1,320
		77	342	234	108	31·4	1,380
		111	408	274	134	32·8	1,380
		132	438	304	134	30·6	1,440
		177	516	362	154	29·8	1,430
		225	576	422	154	26·7	1,440

Curve A. We note that the heat transfer rises sharply to a definite maximum at 40,000 B.Th.U. per hour input, after which further increase of mixture feed leads to no appreciable increase in heat transfer.

This phenomenon which indicates a reduction in flame temperature has been ascribed by Leason to turbulence at the point of combustion. At the point of maximum heat output which will correspond to fully turbulent conditions in the cold mixture stream, the Reynolds number has a value 3,070. It will be noted on the curve that there is a definite change in direction at a heat input of 24,000 B.Th.U. at a Reynolds number of 2,000. These figures are a good indication that turbulence is playing a big part. Moreover the following tests tend in the same direction. It was decided to make some burners with narrower slots, keeping the burner port constant and so to get mixture flows of lower Reynolds number. Two burners were constructed with slots of width ·017 in. and ·008 in., the latter being a strip metal grid. The results of tests on these burners are given in Curves B and C (Fig. 1) and certainly show considerable increases in the capacities

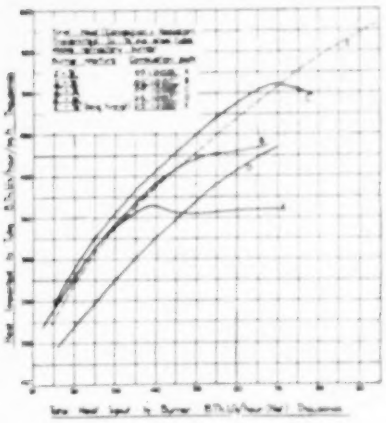


Fig. 1. Graph showing heat transfer performance

of the burners with diminishing width of slot.

The somewhat indefinite form of these curves seems to indicate that turbulence due to slot width may not be the only disturbing factor at higher mixture feeds, but that tunnel convergence may be playing an important part.

It had formerly been noted that with large slots discharging into a small taper tunnel that the phenomenon of maximum heat delivery had been observed, but we had not tried a small taper tunnel with small slots. This was, therefore, done next, and in Section 2, of Table 1, and as Curve D of Fig. 1, the results are given to show little indications of change in direction and in fact its performance eventually equals that of the narrower tunnel B with its greater mass velocity. In the case of the wider mouth tunnel a greater proportion of the heat is transmitted by radiation. There are thus grounds for supposing that tunnels of smaller taper would be an advantage, and it was decided to make a tunnel of taper 14° included angle and get a mass velocity at the mouth equal to burners AB and C by extending the length of the tunnel to 1½ in. The results are given in Section 3, Table 1, and as Curve E (Fig. 1).

It should be noted that the slots were of ·020 in. width (compare Curve B) so that a considerable improvement is shown by making the tunnel taper less. The change of cross section due to a 14° included angle on a straight tunnel corresponds to that due to a 7° included angle on a circular section and is, therefore, in harmony with general practice. With small taper tunnels there does not seem to be much point in making the slots less than ·020 in.

Of the various burners constructed we may regard the performance of that marked E as typical and summarise it as follows:—

Air pressure, lb. per sq. in.	½	1	2	3
Gas consumption, c. ft. per in. length of tunnel	27	39	55	66
Gas rate, c. ft. per sq. in. tunnel aperture for ½ in. wide tunnel	216	312	440	528
B.Th.U. developed per c. ft. of tunnel space—millions	40	58	82	93

Miscellaneous Considerations

One of the most important considerations is the life of the refractories. As regards the tunnel walls the temperature will be as shown in Table 3 varying with rate of working but is well within the scope of the

high grade sillimanite used. The slotted grid is at a much lower temperature, and trouble is not anticipated here. Burners have been in use (40 hours per week) for a year under rather disadvantageous conditions with very encouraging results. Some readily replaceable unit construction which could be pre-fired and cemented into position as required, seems to be called for.

Coupled with this question of life is that of the strength of the refractory block. For low pressure working up to 2 or 3 lb. there seems to be little doubt (though it has not been made the subject of test) that the refractory is strong enough. For high pressure working extra support of the refractory, with possibly a metal grid, may be required.

Another important consideration especially where the burner has to be tended, is that of noise. At low ratings, up to 2 lb. air pressure, the burner would be regarded as quiet. Above about 4 lb. air pressure the noise would not generally be permissible.

Some Industrial Applications

Silver Soldering (Brazing)

A number of burners have been supplied or are on order for the silver soldering of components of oil lamps. Such operations require the precision and shape of the flame more than intensity other than that of correct mixture adjustment. Air pressures of 1 lb. per sq. in. are adequate. With such small tubular and pressed assemblies mounted on a turntable and 2 in. slot burners directed across the work, fusion times of 40 to 60 sec. are attainable. A fair degree of overheating is found to be possible, a component fused at 40 sec. being unharmed by 60 sec. heating so that with proper attention wastage should be reduced, the process can be fully mechanised or left to individual attention.

A brass boss to be soldered to the centre of a ½ in. brass tube by two silver solder rings required 50 sec. for the first ring and 10 sec. for the second on rotation into position. The total gas consumption for the two burners required was 50 c. ft. per hour. Semi-skilled labour could be employed.

Local Annealing

A firm of manufacturers of steel blades required a local softening of a narrow strip 2 in. × ¼ in. wide across the handle—a time of 18 sec. not to be exceeded. A time of 15 sec. was attainable, the gas consumption for the burner being 100 c. ft. per hour.

Local Hardening

Experiments are on hand for the local hardening of two cutting edges of special cutter blades of section about 1 in. × ¼ in. This relatively heavy section requires about 80-95 sec. for bringing the edges to hardening temperature at 11 lb. air pressure.

Edge Fusion

A great deal of experimental work has been performed on edge fusion of glassware for which the burner was originally devised. This work is still in hand.

Conclusion

It is felt that this burner is capable, perhaps in a somewhat restricted field, of rendering some very good service in industrial heating. The essential features of its design have been established by the means described, and its performance coincides with the maximum effort of which forced convection, assisted by radiation, is possible. Though simple in outline it yet remains for us to put its construction on a really sound basis.

I have to thank the Authorities of the West Midlands Gas Board, through the Industrial Gas Officer, for permission to give this Paper and to acknowledge much help and advice from colleagues in the Industrial Department at Birmingham. In particular I should mention the name of Mr. W. Coull, whose assistance has been invaluable.

A Paper read before the Midland Junior Gas Association, 28th March, 1950.

J. Wilson.—Mr. J. Wilson, of Hillview, High Bonnybridge, who died on 24th August, at the age of 80 was for many years a leading figure in the area. He was formerly works and mine manager of the Bonnybridge Silica and Foreclay Co. Ltd., and an authority in the industry in this part of Scotland. He was a J.P. and a member of the Stirling County Council for many years.

BUILDING RESEARCH CONGRESS

THE Rt. Hon. Viscount Samuel, P.C., G.C.B., G.B.E., has consented to be the President of the Building Research Congress to be held in London from the 11th to 20th September, 1951. This Congress will be the first of its kind and its purpose is to review the progress made in research relating to architecture, building and branches of civil engineering.

Many of the papers presented will be by authors from overseas. The first division of the Congress will cover engineering and structural aspects of building. The second division concerns building materials and the third with factors affecting comfort.

Three specific types of buildings, namely, hospitals, factories and schools will develop the above considerations in detail. Enquiries should be made to the Building Research Station, Bucknalls Lane, Garston, Nr. Watford.

HANCOCK CUTTING MACHINES

UNDER the above title, we have received a brochure from Hancock and Co. (Engineers) Ltd., Progress Way, Croydon, Surrey.

It offers a brief outline of the developments in modern oxygen profiling. For more than 30 years the Company have been exclusively engaged in developing and manufacturing cutting equipment concerning this process. Under the name "Hancoxygen," the affinity of iron for oxygen when the former is heated to about 900° C. is relied upon to give a cutting effect. Coal gas, acetylene and propane may be used as fuel gases, whilst the speed of cutting turns upon the thickness of the material and the composition of alloy steels. As an example, mild steel can be cut at 20 in. per minute for ¼ in. thickness to 5 in. per minute for a thickness of 8 in. using oxygen and coal gas.

Description and illustrations are given of the standard machines, together with specification details, covering the cutting area, the cutting thickness and the floor space.

Altogether this brochure covering as it does the process, including longitudinal profilers, the Simplex machine and the U.T.4 tracer head, is a most useful shelf acquisition for the engineer.

ABRASIVE RESISTANT ALLOY

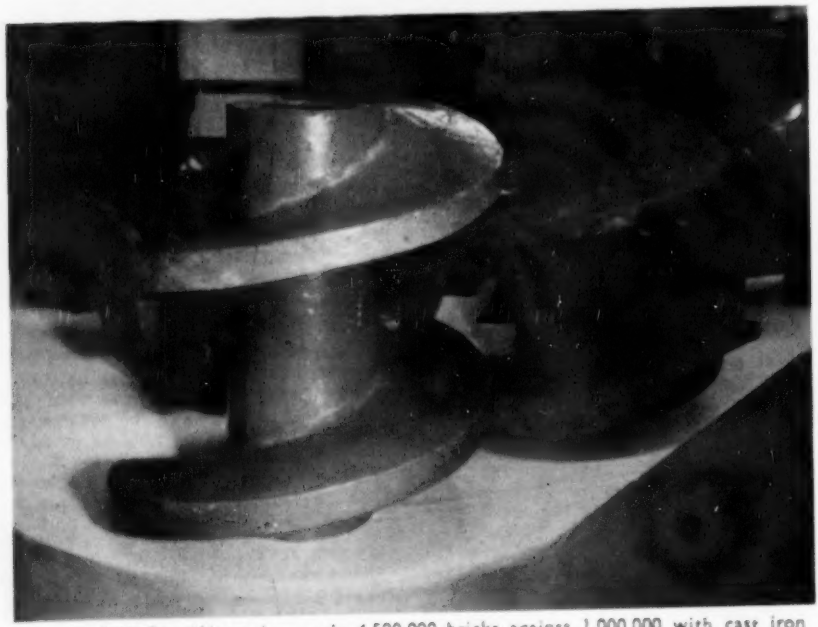
C.Y. alloy made by Follsair-Wycliffe Foundries Ltd., Lutterworth, Nr. Rugby, is an alloy cast iron subjected to heat-treatment and, unlike chilled iron, which is hard only to a small depth, it is consistent throughout. It is not excessively hard, but is relatively tough. This combination of suitable hardness and toughness giving long wear resistance.

Although not sold as a shock-resisting metal, if the section is of a solid type, then, owing to its tensile strength the alloy will withstand considerable shock. Unlike manganese steel, which is a relatively poor abrasion resisting material unless subjected to hammering or working to "work harden" its austenitic structure, the abrasion resisting properties of C.Y. are inherent in the metal as produced. For this reason, in cases where only a rubbing action is applied, e.g. chute plates, scrapers, etc., C.Y. lasts considerably longer than manganese steel, which tends to wear away before becoming "work hardened."

The alloy is magnetic, and can be removed by magnetic separators. It is supplied only as castings for it cannot be forged or rolled. Welding is undesirable although certain solid types of castings can be welded if precautions against cracking are taken.

With suitable medium and heavy type machine tools, the alloy can be turned, bored and drilled and (much less easily) shaped and planed, but, as might be expected with a material designed to resist abrasion, it is desirable to reduce machining as much as possible. A slow speed and fine feed should be employed and tungsten carbide tools are an advantage.

The physical properties are as follows:



"... a C.Y. Pug Worm has made 4,500,000 bricks against 1,000,000 with cast iron components

Ultimate tensile strength 30/35 tons per sq. in.
Brinell Hardness 250-475.
Specific gravity 7·6.
Weight per c. in. ·28 lb.

Use for Brick and Tile Works

Certain brick machine spares are subjected to very severe abrasive wear, renewals involving considerable material and labour costs and in addition causing considerable loss of output. Patterns for spares for many well-known brick machines are available and are continually being added to the range.

Users of the alloy have expressed satisfaction. One says that C.Y. pug worms last six times as long as those made from other material. Another is obtaining excellent results from C.Y. augur knives, while a further comment was to the effect that C.Y. scrapers have been in use 14 weeks and are showing little sign of wear, whilst steel scrapers were worn out in 4 weeks.

A well-known Midland brickworks stated that a C.Y. pug worm made 4,500,000 bricks, whilst the average number of bricks made by cast-iron worms was one million.

Typical parts supplied in C.Y. include mixer knives, pug knives, augur knives, double and treble wing knives, worms, scrapers, dead plates, rollers, etc. In general the alloy is very suitable for all parts subjected mainly to abrasion.

One factor of interest, particularly to pipe makers, is the ability of the alloy to "polish up" very quickly. A new worm, for example, enables full production of pipes to be obtained much more quickly than with other metals. This factor is of considerable benefit for worms and mixer knives.

The alloy is being used extensively for machinery in quarries, gravel pits and the concrete industry, and especially those engaged with crushing the more abrasive materials such as silica, basalt and flint.

Breaker bars and liner plates for Parker Kubit and other types of impact crushers are being manufactured in C.Y.

Toggle plates for jaw type crushers in quarries are made from the alloy for it withstands the considerable pressure exerted upon it, but unlike steel, C.Y. will fracture if an exceptionally severe shock which would normally fracture the framework of the machine is experienced. In this respect its action is rather like a shear pin, but it is reported that the toggles outlasted chilled iron by five times.

At a well-known sand pit, C.Y. side plates in use on a 4 in. pump, pumped 6,800 c. yds. compared with 3,500 c. yds. when chrome steel was employed.

APPEALING TO AMERICAN TASTE

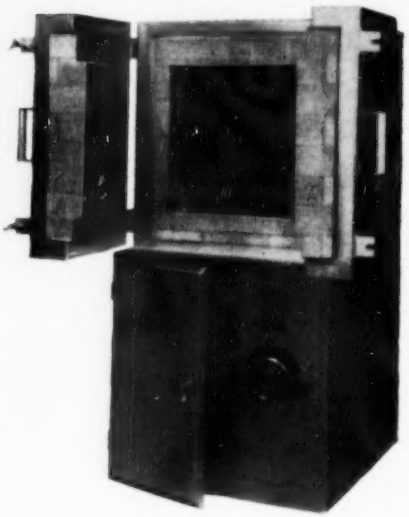
BOOTHS Ltd., of Tunstall, Staffordshire, the old established earthenware manufacturers, are the pioneers of a new method of attracting American dollars. Place settings have for long been popular with the American public who likes to buy its tableware on the basis of a few pieces at a time, adding to the initial purchase from time to time as the need arises. The American householder does not insist that his dinner or tea service is all of the same pattern; in fact, he prefers to buy the few main pieces and build round these as and when occasion demands.

The new packaging for the American market pioneered by Booths Ltd.

Booths' place settings consist of five pieces of tableware—three plates in sizes 10 in., 6 in. and 4½ in., together with a cup and saucer. They are neatly packed in an attractive and easily handled container. There is a wide selection to choose from in any of Booths' twelve patterns including their "Real Old Willow," "Blue Peony," "Flowerpiece" or "British Scenery"—patterns which are based on the work of early 18th century artists. This is a real attempt to cater for the American taste and has meant much thought and market research. Not the least important factor has been the designing of a carton which combined the qualities of lightness, strength and compactness. This was developed in consultation with the well-known packaging firm of Alfred Kent and Sons Ltd., London, the colour of the carton—royal blue—was chosen on the advice of a team of designers including Bernard Ronchetti, Endre Hevezi and Dr. Gyula Bajo, who considered that this particular shade would prove complimentary to any of Booths' twelve patterns. The gold stamp on the outside lid of the carton was the work of Gee Advertising Ltd., Leicester, who are Booths' advertising agents. These place settings will be on sale at leading retailers throughout America.

GRAFTON DECORATING KILNS

WE have received an interesting leaflet, describing the above, from The Applied Heat Co. Ltd., Elecfurn Works, Watford By-Pass, Watford, Herts.



The Grafton Decorating Kiln

There is a standard range of small kilns for decorating, on-glaze enamelling, etc., up to 850° C. The kiln atmosphere is clean and free from sulphur. The elements are carried in grooved refractory bricks and are easily replaced. The door design includes fixing clamps to press the door face up to the kiln mouth and at no point is the brickwork rubbed. It is fitted with rheostat control and the gentle heat from this provides the heating medium for the pre-heating chamber. The decorating kiln is illustrated here and the leaflet specification gives details, including overall and internal dimensions, power ratings and shipping particulars.

IRON MARCHES ON

LLOYDS Ductile Iron is produced by the addition of nickel-magnesium to molten iron, to provide residual magnesium. The influence of magnesium causes the coarse graphite flakes to be suppressed and replaced by spheroids. Since the optimum form of graphite is a sphere, the replacement of weakening flakes by nodules, gives a new material, of great strength, ductility and a good shock resistance, fluidity, castability and ready machinability.

It means that there is now obtainable, a cupola or other furnace product with a tensile strength between 35 and 45 tons per sq. in. with elongation up to 5 per cent. in its "as cast condition." Short term heat treatment at sub-critical temperatures greatly increases ductility and gives tensile strength of 30 to 40 tons per sq. in. with elongation values up to 15 per cent. and even higher.

Applications

The field of application of Ductile Cast Iron includes castings now being made in malleable iron or steel. Such castings as lifting clamps for handling heavy ingot moulds, pump rocker arms and hangers for applications requiring high strength; brake shoes, Wheelabrator hooks and shake-out hammers, where toughness or resistence or impact stresses are required; brakedrums, permanent moulds and pig slabs, where resistance to high temperature and thermal shock is the determining factor; electric motor fans, cylinders for use with forging hammers, compressor heads weighing up to 1 ton; clutch plates and many castings used in the manufacture of agricultural machinery.

In a booklet with the above title, obtainable from Lloyds (Burton) Ltd., Wellington Works, Burton-on-Trent, further information on Ductile Iron is available.

AMERICAN COMMENTARY

A "CERAMICS" FEATURE

One-coat Enamelling—The need for improved methods and equipment

IN our May issue we reviewed the development by the Westinghouse people of a practical one-coat enamel process as outlined in *Ceramic Industry*.

In an honest report of their more recent activity this highly progressive American Company has stated to the same journal:

"Although the one-coat direct-on-steel process is a reality and a definite success, experience at the Westinghouse Mansfield plant shows there are still short-comings in equipment, still imperfections in the steel and snags in enamel milling, metal cleaning and firing."

First, of course, are the short-comings in the titanium steel itself, the short supply of the special metal being the biggest single deterrent to immediate wider adoption of the one-coat method. Even if the steel were available in ample supply, however, its high cost is a drawback and the enameller can only hope that as production increases, steel companies will develop production economies.

Better Metal not Sole Need!

Frits, for example, although by far the best ever supplied, could stand improvement. One-coat enamellers are dogged by the need for cover coats which will flow out better and will not pit or "egg-shell." Lower maturing enamels, are of course, still desirable.

Further, production equipment is far from perfected. Pickling by most normal methods is inadequate. Complete metal cleaning is essential for defect-free one-coat, and dip pickling falls short of this goal. Improved spray pickling systems would appear to be the best answer to the problem.

The actual application of the coating requires attention both of the one-coat enameller and the spray equipment manufacturer. The single coat process, to reach perfection, needs the water-wash pressurised spray booth using filtered and dried air.

Extreme orange peel effects which trouble the one-coat enameller are partially due to the failure of enamels to flow out, but could be remedied largely by a spray gun giving a very smooth initial coating. Recently developed low pressure spraying techniques give encouraging results but improvements in gun design are still needed.

Slot in Hearth has Advantages

Furnace imperfections and the defects resulting therefrom are common to all enamelled ware. Even the use of perfect, inert steel and the best of enamels could not prevent defects due to chain droppings, uneven temperature gradients, etc., and the slot-in-hearth furnace would seem to supply the nearest approach to a solution of these problems to date.

The mill room and conventional milling methods fall far short of matching the near perfection of today's raw materials.

Westinghouse are doing a grand job of practical pioneering. Results will be worth watching.

TILES OF HAND MADE QUALITY

Extensive checks on body composition, shrinkage, porosity and raw materials carried out in the control and development laboratory of the Pacific Tile and Porcelain Co., plant at Paramount, Calif., make possible the mechanical production of tiles hitherto left to hand fashioned ware. Incoming body materials are checked in 500 lb. test batches to determine the uniformity. Glaze materials are tested in batches against standard camparitors.

Pacific Tile and Porcelain's Cera-Tile division was set up with two prime purposes. The first was to produce a decorative tile, unique in colour, texture and design, yet fulfilling top quality standards at a minimum cost to consumers. The second was to provide a service to architects, designers and contractors for contract work straight through from design via production right up to actual installation.

Method

After Cera-Tile designers have made the master design it is sent to a screen maker who cuts a Pilofilm mask which is adhered to a silk screen. The specially prepared colour compositions going into the design are then hand "squeegeed" through the silk screen directly on to the bisque tile.

Following silk screening, the imprinted tile goes to any one of the three automatic spray lines for application of a single white or stained opaque glaze. This overspraying is possible because all colour effects, both imprinted material and overspray, are controlled by composition.

Prior to overspraying, the Cera-Tile is permitted to air dry for 24 hr. After this period, the screen printing will not rub or chip off, thus making for easy handling throughout the spraying operation. It is this handling ease, together with the semi-automatic technique, that enables the mass production of Cera-Tile without loss of the appearance of hand decoration. Best of all, it has cut costs to approximately half those of hand decorated tiles.

Further Development

Pacific Tile and Porcelain's affiliate, Cerametel Corp., has another radically new process under way on which patents are pending. This development concerns the reduction of metallic oxide suspended in glass to a free metal state. The process makes possible a glaze, seemingly of the metal itself, fired to the body to be decorated. Experiments in gold, silver, copper and bronze have all been successful.

MECHANISED BATCHING FOR UNIFORM GLASS

At the Armstrong Cork Co., site at Mervilles, N.J., tremendous strides have been made towards the ideal glass batch plant.

Fundamentally, a batch plant is assigned the task of receiving, storing, weighing and mixing batch ingredients thus supplying a more uniform glass to the forming machine.

Prior to the construction of the new plant, Millville had been making-do with a 60-year old plant. Built to handle 50 tons of batch in 24 hours, it had for several years turned out six to eight times that amount with a crew of thirty-three men. The new plant operates with a maximum of thirteen men, its capacity greatly exceeding present demand.

Rotary Table Controls Batching

The control mechanism of the automatic batching cycle is a device best described as a rotary batch-selector. It is made up of fifteen selector cans containing colourants or decolourisers moving on a time cycle. At control points electrical contact is made by removable buttons fitted to the cans. The table actually performs four functions; it

selects the formula to be batched, starts the weighing, dumps the colourants or decolouriser to the collection belt, and selects the furnace destination for each batch.

The Operation

Probably the best way to explain the system is to follow through a complete batch. Say, for example, we have the selector can for "C" tank approaching the control point on the table. The batch-tube selector button is in the slot in the red band which is the colour for "C" and the "formula selection" button is in its correct slot. Our "C" batch-can makes contact with the "formula selection" button and the corresponding beams at the scales are dropped. The scale pointers immediately drop to the underweight position. At the same time vibrating feeders start to deliver materials to the scale hoppers. As the pointer reaches balance it intercepts a light beam focussed on an electric eye and shuts off the feed. Discharge is accomplished by vibrating feeders at the bottom of the scale hoppers. Contact is also made to select the proper batch tube for this "C" tank batch.

The materials are all discharged to the collecting belt (sand and chemicals first and cullet last), and then elevated to a surge bin. The mixer which has been mixing the previous batch, after discharging to the batch tube, takes out "C" batch automatically on returning to the mix position.

Five vertical batch tubes receive mixed batch and hold it for pickup in batch cans brought to their discharge end by lift truck.

Precision for Critical Chemicals

Weighing of decolourisers and/or colourants in the rotary table is an important stage in the process, and Armstrongs have devised a remarkably efficient system. In the entire cycle, this is the only non-automatic operation. The operator, using small platform balances, weighs out the chemicals early in the shift, placing them in colour-keyed buckets according to furnace destination. They are then transferred to selector cans in proper sequence, their contacts being set to correspond to formula and tank destination.

Safety Measures

Safety devices and mechanisms are essential in any automatic system, and considerable safety measures are in force on the batching cycle, some of the more important ones being as follows:—

1. If for any reason one of the scales does not function, the entire system is held up when all the other scales have reached the balance. This prevents a batch with a missing ingredient.
2. In general, all units of equipment such as mixer, mixer tilt, surge bin gates, etc., have to be "satisfied" before the rotary table will move to the next position.

The Armstrong folk admit to experiencing certain initial "Teething troubles" as occur in all new ventures of this kind, but these have been overcome. Nothing was spared to provide the most modern batch plant in use today. The results, we are assured, were well worth the effort.

STRAIGHT-LINE FLOW LOWERS TILE OUTPUT COSTS

Putting the mill next to the market is still good industrial practice. Stylon Corporation with its new ceramic floor tile plant not only believe this but their belief has been backed by installing on the outskirts of Boston, good equipment arranged to provide straight-line flow of materials and product.

Duplicate Mixing Lines

The mixing installation is composed of two complete and individual lines of equipment. From the nearby storage area, palletised bags

of air-floated and purified clays, spar and other materials are brought to the mixer platform by lift truck and weighed into a mixing bed for preliminary pre-mixing. Here it is held until the big mixer is ready to receive a new load.

Pre-mixing completed, the material is transferred into a "Lancaster" mixer for the water and binder additions and a 15 minute agitating period. An inclined, troughed belt conveyor then carries the batch from the mixer and dumps it into a "Sturtevant" mill for pulverising. A square metal hopper is situated below the mill and when filled is fork trucked out of the mixing room to the presses.

Friction presses equipped with multiple place dies are sited adjacent to the mixing room and form the floor tile shapes.

The plant's pair of straight tunnel kilns extend down one side of the long building. One kiln of the muffled type is used for the more sensitive, light colours. The other, larger kiln is direct fired to 2,200° F. and handles the bulk of the plant's production. Oil fuel is used on both. No glazing is done, all pieces being once-fired.

Separate Room for Dark Hues

An effective system of isolating the batch mixing and pressing of black, dark shades and natural clay colours has been worked out. These tiles are prepared in a separate room adjacent to the main plant using separate mixing machinery and pressing equipment—a precaution taken to avoid all possible chance of rejects in light-coloured pieces.

Using special vibrating machines the plant has mechanised the task of sorting ware. The unit consists of an inclined vibrating table made up of a series of small "V"s. When a saggar of fired ware is dumped at the top of the vibrating table, the setting sand drops through openings and is caught in a hopper. Good, well-fired tiles are held for a short time until the vibrations shake them farther down the table where they fall into small ware-boxes. Tiles which have stuck together in firing remain on the table top until they are caught in a trough at the end of the incline and spilled into a waiting reject box.

The plant manager is quoted as saying that the expected big headache of starting production with workers new to ceramic trades had failed to materialise.

CIRCULAR SCREENS INCREASE PRODUCTIVITY OF TILE PLANT

Operating on a new, recently developed principle, a vibrating screen for lawning slip has been installed at the Glendale, Calif., plant of Gladding, McBean and Co. Developed by the Southwestern Engineering Co., of Los Angeles, it had been used extensively for some time in the handling of oil field drilling muds.

The ever increasing demand for Gladding, McBean "Hermosa" tile, enforced changes in spray drying apparatus in order to increase the production capacity, and the available space was insufficient to allow installation of additional conventional screens. Accordingly, investigations were conducted to determine a means of increasing lawning capacity without sacrificing space and mesh size, or lowering of the specific gravity.

Mesh Sizes

To obtain the required purity of product, Gladding, McBean and Co. find it desirable to lawn through not less than 120 mesh, and preferably through 150 mesh. With conventional horizontal vibrating screens, experience indicated that a specific gravity of 1·40 was about as heavy a slip as could be efficiently handled through 120 mesh. To lawn through 150 mesh

meant a sacrifice of specific gravity but in the operation of a spray dryer the capacity is increased by increasing the specific gravity of the slip handled. With the installation of the new screen equipment, it has been possible to increase the specific gravity of the slip to 1·45 and to replace the 120 mesh screens with 150 mesh, maintaining the same rate of flow. This provides not only a cleaner body, but increases the capacity of the spray unit without any increase in floor space. Results of tests at present in progress indicate that it may be possible, through additional deflocculation, to increase the specific gravity still further.

The screen itself, occupying a space roughly 4 ft. in diameter by 4 ft. high, is driven by a horizontally mounted eccentrically connected motor. All parts of the unit in contact with the slip are constructed of monel metal, the screens themselves being stainless steel.

INTERNATIONAL COMMITTEE FOR THE STUDY OF CLAYS

AN International Committee for the Study of Clays (C.I.P.E.A., "Comité International pour l'Etude des Argiles") has been formed with the aim of grouping specialists in the study of clays, from whatever angle, in different countries. They were represented on the Committee by a maximum of two members per country.

An executive sub-committee was appointed in London during the recent Geological Congress, and consists of four persons: S. Henin (France), chairman; M. Lepingle (Belgium), secretary; R. E. Grim (U.S.A.), member; D. M. C. MacEwan (Great Britain), member.

The aims of the Committee are to collect a full documentation on the results and methods of clay studies; to promote contacts between specialists in such studies; to organise conferences from time to time, in which questions relevant to clay studies will be discussed, aiding specialists to compare their results and to unify their methods of description. The Committee will aid in bringing about exchanges of reference samples between research workers and will try to define the terminology and methods used in the scientific study of clay.

With these ends in view, they hope to obtain representatives in each country who will maintain contact between the International Committee and the research workers there, whether grouped or not in a regional organisation. Several national committees of this type, devoted to clay studies, have already been formed, notably in Belgium, France, Great Britain and Sweden.

Questionaires on the various subjects within the scope of the International Committee will be sent to its representatives, who will be charged with circulating them in their respective countries and collating the replies obtained. A first enquiry of this type concerns differential thermal analysis, and a special sub-committee has been formed for the purpose.

The British representatives are Dr. D. M. C. MacEwan (Rothamsted Experimental Station) and Dr. G. W. Brindley (University of Leeds).

HEAT RESISTANT PAINT

ALUMINIUM protective coatings which provide a brilliant appearance and which withstand high temperatures are now being marketed by Factron Products Ltd., 14 North End Road, N.W.11. Their aluminium paint range includes a development which has been evolved for use on surfaces subjected to dry heat temperatures of 900° F.

Some idea of the heat resistant qualities of this product can be gained from the manufacturers' application instructions where they recommend playing a blow-lamp over the applied film in order to raise the surface temperature as high as possible between coats, as maximum temperatures produce especially brilliant and lasting results. Designed for use on boilers, radiators, chimneys, heat conducting pipes, exhaust manifolds, foundry plant and equipment, etc., special attention has been given to the elasticity, strength and adhesive qualities of this paint.

Full particulars, prices and descriptive leaflet can be obtained from the manufacturers.

Newcastle-on-Tyne.—Richard Sutcliffe Limited announce that their Newcastle office is now established at 17 Sandhill, Newcastle-on-Tyne.

Experimental Firing with a Short Multi-passage Kiln

by

W. L. GERMAN, M.Sc., Ph.D. (Lond.), F.R.I.C.

THESE experiments were carried out in a small multi-passage kiln 30 ft. long, working on the Gottignie principle. Kilns of this kind have been working on the Continent for the past 10 years with conspicuous success.

Briefly the idea is that the cross section of the kiln is reduced, thereby cutting down convectional heat losses and also, since it cuts out temperature inequalities in the kiln load, permits the heat work to be done in a much shorter time, thereby speeding up the firing schedule. This gives higher kiln efficiencies, resulting in lower firing costs.

Outputs comparable with the kiln of larger cross section are obtained by increasing the number of passages and while the prototype on which this work was done had only four passages, the usual industrial units have 16, 24 and 32 passages, operated in counter-flow.

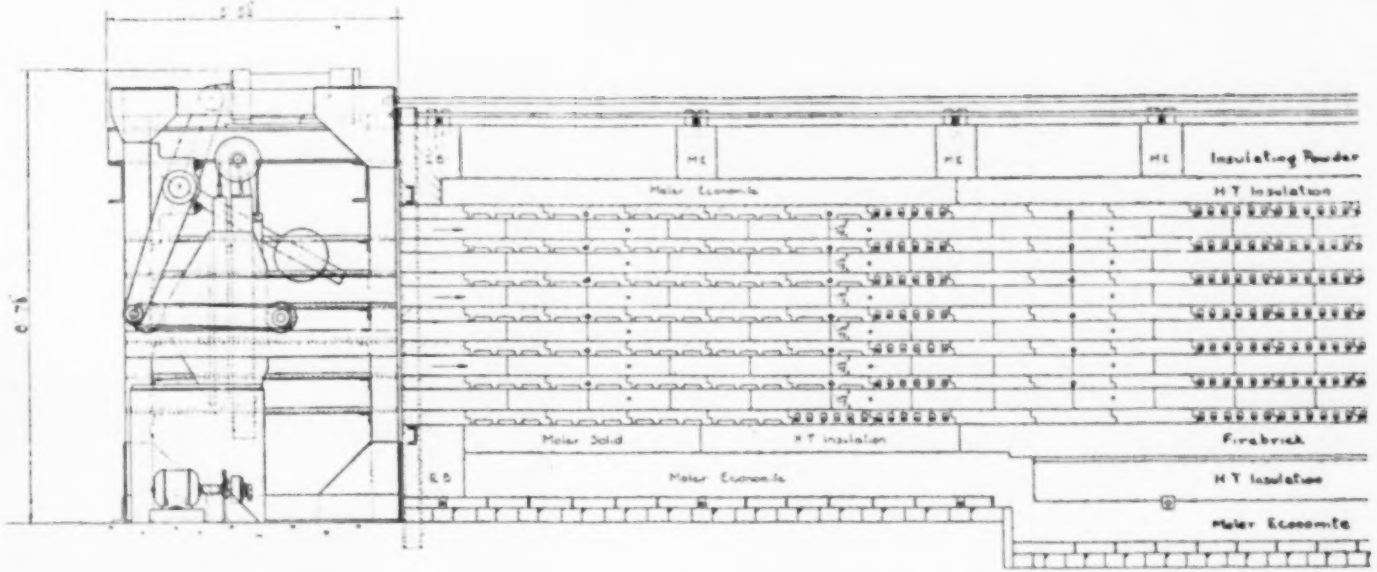
The counter-flow principle is very important in reducing heat losses, as is shown later by the high thermal efficiencies obtained with these kilns.

Part of a lecture given at the Imperial College of Science and Technology, S.W.7, on 28th September, 1950, in a short course entitled "The Firing of Bricks."

Movement of Ware

The ware is loaded on refractory bats made by pressing by the

The first Gottignie multi-passage kiln built in this country, by Gibbons Bros., for J. H. Barrett and Co.



Half section of Gibbons-Gottignie multi-passage kiln

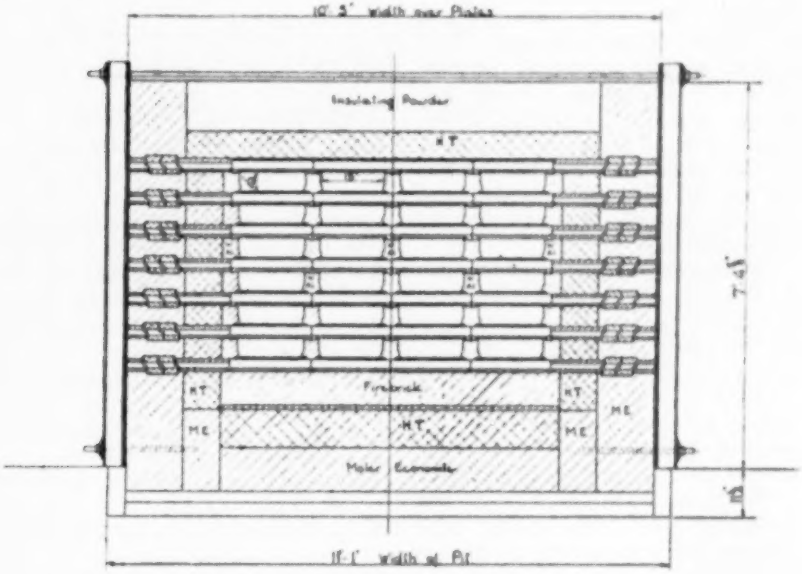
24 passages. 15 in. wide by 4½ in. high

Overall length of kiln brickwork 38 ft. 6 in.

semi-dry method, using a 40-ton press. Satisfactory results have also been obtained in this country by casting. The bats are about ¾ in. thick, and it is important that opposite edges should be ground parallel, since otherwise the bats do not move in a straight line when pushed one against the other, and contact with the tunnel wall may result in a wreck. Clearing these in a small passage is a disagreeable operation.

of a large kiln of this type is about 10 ft. by 8 ft. with up to 32 passages. These are normally approx. 15 in. wide by about 6 in. high, though the actual dimensions can be varied somewhat to suit individual requirements.

The loaded bats carry about 5 lb. weight of ware and kiln furniture (if required), and since the tunnels operate in counter-flow, it is important to maintain even bat loading or



Section through Gibbons-Gottignie kiln

For the same reason the mix used in the bats should be able to stand thermal shock, as broken bats are also a potential source of trouble.

The bats slide on the floor of the passage, impelled by a suitable ram, usually operated by hydraulic pressure. The bat is normally softer than the material forming the passage of the kiln for obvious reasons, and the crushing strength of the bats limits the length of tunnel that can be operated successfully.

Dimensions

Normally these are between 30 ft. and 40 ft. The overall cross section

temperature fluctuations result.

Advantages of Kiln

Such a small kiln is very attractive in works where space is at a premium and there is no possibility of enlarging the premises. Other very solid advantages are the low power consumption, and the fact that no expensive foundations are necessary. The latter is a very considerable advantage in areas subject to mining subsidence.

The accompanying illustrations show the first Gottignie multi-passage kiln built in this country, at Stoke-on-Trent, by Gibbons Bros.,

Dudley, for J. H. Barrett and Co. Ltd. the tile manufacturers. It has twenty-four passages and fires glost tiles. A prototype kiln with only four passages was the one in which experiments described in this paper were conducted.

Heating

In each case the heating is done electrically by elements, which are made from Kanthal or Nichrome wire. These rest in holes in the refractory tiles which form the top and bottom of each passage. The elements do not appear in the tunnels at all, and heating is at top and bottom only. Current is transformed down to about 60 v. and is picked up from four bus bars on the side of the kiln. Transforming down the current prolongs the life of the elements.

The metallic resistors pass across the kiln and are connected in pair. by a metal strip. A burnt-out one can be replaced by simply disconnecting, pulling out the pieces, and inserting a new one, all without cooling the kiln. If necessary the elements can be connected to thermostats operated by thermocouples. In the latest type the elements and pyrometers are housed in the same aperture and overheating of the wire is avoided.

Performance on the Continent

Table 1 gives some idea of the uses of this kiln in Continental factories. It has been used to fire biscuit and glost wall tiles, quarries, earthenware, and vitrified grinding wheels.

The fuel consumption is noteworthy. As far as pottery is concerned it is considerably lower than that obtained in the conventional tunnel oven and with biscuit wall tiles the figures compare with those obtained with a large gas-fired oven using open setting.

Summarising this data we get the following:—

Ware	*Temperature °C*	*Cost per ton of ware*
Glost wall tiles	1,080-1,100	14/6-19/11
Biscuit „ „	1,250	18/2-23/8
Floor Quarries 4" × 4" × ⅝"	1,120	17/3
Floor Quarries 4" × 4" × ⅝"	1,260	17/0-22/0
Floor Quarries 6" × 6" × ¼"	1,175	17/3
Biscuit table-ware	1,250	26/0
Grinding wheels	1,245	70/0
Bricks 8½" × 1¼" × 2½"	1,050	13/0

These figures are calculated on a figure of 0·6d. per unit.

Comparison with Other Types

Comparable figures obtained in this country for wall tiles and table ware are shown in Table 2.

It will be seen that the firing costs with a multi-passage kiln are considerably lower. This being due to the higher percentage heat efficiency and as has already been indicated, this is due to:

1. counter-flow of ware giving heat recuperation;
2. small tunnel cross-section, avoiding convection heat losses;
3. shorter length; cutting radiation heat losses;
4. shorter firing schedules possible.

Experimental Firings in Four Passage Prototype Kiln

It now remains to give an account of the experiments carried out in the small prototype Gottignie type kiln. Although it had been proved successful for work with tiles, there was very little data which gave any clue as to whether it could be adapted to general earthenware and other kinds of goods.

Bearing in mind that every manufacturer has a percentage of tall hollow-ware, the first version of the experimental kiln had two passages 10 in. high and two 6 in. high. With this set up it was possible successfully to fire tall biscuit and glost hollow-ware in a kiln 30 ft. long.

TABLE 1

OPERATING DATA OF PASSAGE KILNS BUILT BY GOTTIGNIE

Ware	Operation	°C. Temp.	Kiln Length (m)	(mm.) Passage Width	(mm.) Passage Height	No. of Passages	Cycle (hours)	Setter Loading	Output per day Gross ton	Output per day Net ton	Consumption (KWH) per Quantity	Consumption (KWH) per Hour	Gross ton	Net ton	Cost per net ton at 0·6d. / unit. (shillings)	Ventilation
1st Firm																
Wall Tiles																
Dec. 1938	Glost	1,080 / 1,100	10	210	105	24	12·8	4T + C	6·35	3·35	16,000	40·8	155	294	14·7	Medium
Sept. 1938	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	145	300	15·0	,,
No. 1 Kiln March 1949	,,	,,	,,	,,	,,	,,	15	5T + C	5·4	2·97	10,800	47·45	211	384	19·2	Large
No. 2 Kiln March 1949	,,	,,	,,	,,	,,	,,	16·3	4T + C	4·5	2·22	8,080	36·9	196	398	19·9	,,
2nd Firm																
Wall Tiles	Glost	1,100	10	210	105	24	13	—	7·79	2·85	9,500	33·5	142·5	283	14·1	—
1st Firm																
No. 1 Wall Tiles	Biscuit	1,250	10	210	105	24	18	6T + C	5·14	2·74	10,950	48·5	253	473	23·7	Large
No. 2 Wall Tiles	,,	1,260	11·7	210	105	32	21	,,	10·18	4·12	15,000	73	171·5	425	21·3	,,
2nd Firm																
Wall Tiles	Biscuit	1,240	11·7	390	105	32	26 / 30	7T + C	10·3	6·6	24,500	100	233	363	18·2	Medium
3rd Firm																
Floor Tiles	Once fired	1,120	11·7	260	100	32	28½	4 + C	9·35	5·3	21,000	75	193	342	17·1	Medium
4 × 4 × ⅝	,,	1,260	11·7	380	,,	,,	45	,,	8	5	20,000	83	212	340	17·0	Large
Floor Tiles																
6 × 6 × ½	,,	1,175	11·7	260	100	32	20·3	2 / 3 + C	9·35	5·16	7,360	74	190	344	17·3	Medium
Bricks																
215 × 55 × 30 mm. each 720 grams	,,	1,050	—	—	—	18	19·2	—	7	5	—	—	185	298	13·0	Large
Tableware	Biscuit	1,170 / 1,250	11·7	—	—	24	19 / 24	6 soups or 8 dinner	—	3·5	—	75	—	915	25·7	—
Grinding Wheels 16 in. dia. × 2 in. thick—22 lb. Setter weight 24·9 lb.	Once fired	1,220 / 1,245	38' 6"	1' 6"	4"	8	78 hours (corundum) 118 hours (SiC)	1 wheel on setter	2,755 (lb.)	1,300 (lb.)	—	345	662	1400	70·0	—

TABLE 2

GLOST EARTHENWARE AND CHINA

	Up draught intermittent	*Open flame tunnel towns gas*	*Muffle tunnel towns gas*	*Electric tunnel*
Placing	Saggars	Saggars	Open	Open
Temperature °C	1,060	1,060	1,080	1,072
Therms/ton ware	716	232	78	27
£/ton ware for fuel	7·15	5·15	1·7	2·0

EARTHENWARE BISCUIT

	Up draught intermittent	*Down draught intermittent*	*Tunnel open flame town gas*	*Electric tunnel*
Placing	Saggars	Saggars	Saggars	Open
Temperature °C	—	1,110	1,125	1,140
Therms/ton ware	358	262	159	387
£/ton ware for fuel	3·6	2·6	3·55	2·85

BISCUIT WALL TILES

	Down draught intermittent	*Tunnel open flame town gas*
Placing	Saggars	Saggars
Temperature °C	1,105	1,120
Therms/ton ware	215	155
£/ton ware for fuel	2·15	3·45

TABLE 3

SUMMARY OF RESULTS OF TRIALS IN SMALL MULTI-PASSAGE KILN AT N. STAFFS TECHNICAL COLLEGE, STOKE-ON-TRENT

	E'ware glost 2 tnls. 6" high 2 tnls. 10" high	*E'ware glost 2 tnls. 6" high 2 tnls. 10" high*	*E'ware glost 4 tunnels 6" high*	*Vitreous floor tiles 4 tnls. 6" high*	*Stoneware pipes 4 tnls. 6" high*
Period of Test (hrs.)	12	24	14	16	24
Total Power Consumed (units)	488	929	277	354	747·5
Cycle (hrs.)	17	14	14	30	42
Max. Temp. °C.	1,080	1,070	1,050	1,100	1,080
Air Temp. °C.	22	22	20	20	20
Wt. of cranks (lb.)	80	531	423	Not used	Not used
Wt. of bats (lb.)	583	1,532	909	(a) 119·5 (b) 268·9	789
Wt. of ware (lb.)	604	1,050	490·5	(a) 36·5 (b) 815·6	778
Moisture in ware %	0·91	9·91	1·0	9·50	1·0
Ratio ware / furniture and bats	1:2·1	1:1·96	1:2·7	3:1	—
Overall thermal efficiency %	49·5	51	96	(a) 113·6 (b) 85	36·7
Heat in bats, etc., %	20·5	33·5	69·6	(a) 20·1 (b) 15·0	15·9
Heat in ware %	19·0	17·3	26·4	(a) 93·5 (b) 70·0	20·8
Cost of firing ware per ton at 0·6d./unit	£4·52	£4·95	£3·6	£1·875 (average)	£5·45
Setting density of ware (lb. c. ft.)	9·2	11·0	—	—	—
ditto total (ware, bats and cranks)	19·2	32·0	—	—	—

(a) all four passages operating for 4 hr.
(b) one passage blocked after 4 hr. and load static there for remainder of test.

The ware was well fired and losses were normal.

However, it was also evident that with only four tunnels the two passages 10 in. high gave such heat losses by convection that it was impossible to balance up the heat flow in the two sets of passages, and there were always temperature differences. The heat losses too, made the current consumption disappointing, although even so it was lower than with some kilns of conventional design (see Table 3).

Two Trials Made

With this set up two trials were made with earthenware glost fired up to 1,080° C. on a 17 hour cycle. The percentage heat usefully employed in the ware in the first trial was 19 per cent. Cranks and bats accounted for another 20 per cent. leaving 60 per cent. unaccounted for. The overall efficiency calculated according to B.S.S. 1,388 (1947) was 39·5 per cent. and the cost of firing the ware at 0·6d./unit of electricity was £4·5/ton ware. The setting density was 9·2 lb./c. ft. per ware and the ratio of bats and setters to ware was 1:2·1, the average weight on each bat being 6·84 lb. Crazing results were similar to those in ware-fired in other types of oven. A further trial gave a similar result.

The experiments had so far shown that holloware biscuit and glost could be fired satisfactorily through the kiln.

Biscuit Firing

Trials with biscuit soon showed that with flat ware our ideas of placing would have to be changed. When the flat is placed in bungs on the bats there appears to be a critical height above which one or more pieces will be found to crack in each bung on firing. This also applies to biscuit tiles.

The reason for this is probably that with such a short kiln it is impossible to heat up or cool heavy masses of clay so as to avoid cracking at the critical periods in firing. The ware must also be dried thoroughly before firing.

Reconstruction of Kiln

In view of the heat losses from the 10 in. high tunnels it was decided to modify the kiln to one of four passages, each 6 in. high. The immediate effect of this was to cut the power consumption for glost firing of mixed tea ware from forty-four to twenty-five units an hour.

Using this arrangement of tunnels experimental firings were undertaken with earthenware glost, small drain pipes, and floor quarries. The typical results are given in Table 3.

The rise in thermal efficiency in firing earthenware glost was noteworthy, the original overall efficiency being 51 per cent. On making the tunnels smaller this rose to 96 per cent. and this with the same type of ware made from the same body. At this rate the kiln was working on a 14 hours cycle, firing to a maximum temperature of 1,050° C. and giving about 900 dozen of mixed teaware per week (168 hours). The average hourly total power consumption was about 20 units costing 1s. hour at 0·6d./unit, which is a remarkable figure. The ratio of ware to bats, etc., was 1:2·7. This could be improved by using a more up-to-date type of crank.

The fuel cost was 0·366d./lb. ware or 1·43d./dozen for 6 in. saucers and 1·15d./dozen (of twelve) for tea cups.

Floor Quarries

In this trial the bats were loaded rather more heavily than usual and the overall efficiency was greater than 100 per cent. This is possible owing to the method adopted in B.S.S. 1,388 for calculating the efficiency, and indicates that some heat recuperation was taking place. The ratio of ware to bats was 3:1 by weight, and firing took 30 hours (top temperature 1,100° C.). The ware was satisfactory and free from

black cores or bloating.

As already indicated, if the quarries are piled too high on the bats dunting results. With 4 in. quarries the safe limit was eight to ten for ⅜ in. and six for ½ in. thick ware. With 6 in. quarries about four high was the limit. The quarries were well down to size and of a good colour.

Clay Pipes

A number of small drain pipes were fired purely as an experiment to determine whether a particular clay could be fired on a short schedule. This information was needed by a firm of pipe makers, who were contemplating changing to tunnel oven firing for sewer pipes.

The clay was carbonaceous, and hopes of firing it in a tunnel 30 ft. long were not felt to be good. Early samples fixed on a 24 hour cycle to a maximum temperature of 1,100° C. were bloated and so the cycle was lengthened to 40 hours with an oxidation period of 6½ hours. This was also unsatisfactory, and it was not until the oxidation period was lengthened to 9¼ hours that black coring was obviated.

With this oxidation period it was possible to reduce the total firing time to 32 hours, provided the pipes were placed lengthwise along the passage to promote flow of air through them. Needless to say this reduced setting density and encouraged heat losses. The efficiency was not high and the cost of firing excessive. There is no suggestion that such ware could be fired economically by electricity, but it did establish the fact that this clay when made into pipes could be fired in 32 hours, which is a remarkable result. The Bullers ring reading was twenty-eight and the ware had a water absorption of 4·7 per cent. (unglazed).

Further trials are projected with this type of kiln to test its suitability for bone china biscuit and electrical porcelain.

TABLE 4. RESULTS OF FIRING GLOST TILES IN A 24-PASSAGE GOTTIGNIE KILN

Duration of test	24 hr.
Electricity consumed.	2,404 units
Average hourly consumption	100 units
Max. Temp.	1,060° C. (1,940° F.)
Air Temp	68° F.
Wt. of tiles fired in 24 hrs.	12,258 lb.
Wt. of bats, cranks, etc.	20,421 lb.
% moisture in tiles	1·5%
Firing cycle	14 hr.
% thermal efficiency (overall)	200
% thermal efficiency (for ware)	78
Cost of firing ware at 0·6d/unit	£1·1/ton

With earthenware, biscuit holloware can be fired satisfactorily in this kiln. Frequently, too, flat is satisfactory, but there are occasions when a proportion of dunted and crooked ware are obtained. Further work is needed to assess the causes of this and to evolve the best method of open setting flat ware.

Finally, results recently obtained in the twenty-four passage glost kiln firing tiles which has recently been put into operation in this country may be of interest (Table 4). They prove that this kiln is thermally very efficient, and support the view that for firing certain types of ceramic ware it is an attractive proposition.

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